FINAL REPORT

Low VOC Barrier Coating for Industrial Maintenance

ESTCP Project WP-0301

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TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
AIM	Architectural and Industrial Maintenance
AQMD	Air Quality Management District
AST	Aboveground Storage Tank(s)
ASTM	American Society for Testing and Materials
CCB	Construction Criteria Base
CCS	Coating Condition Survey
CPUA	Cost Per Unit Area
COTS	Commercial Off The Shelf
DESC	Defense Energy Support Center
DFT	Dry Film Thickness
DOD	Department of Defense
DPS	Detailed Performance Standard
EICO	Engineering Innovative Criteria Office
EPA	Environmental Protection Agency
ESTCP	Environmental Security Technology Certification Program
FTIR	Fourier Transform Infrared Spectroscopy
HAP	Hazardous Air Pollutant
HAZMAT	Hazardous Material
HVLP	High Volume, Low Pressure
LVBC	Low VOC Barrier Coating
MEK	Methyl Ethyl Ketone
MIL-DTL	Military Detail (Standard)
MIL-PRF	Military Performance (Standard)
MPI	Master Painters Institute
NAVFAC	Naval Facilities Engineering Command
NFESC	Naval Facilities Engineering Service Center
NTPEP	National Transportation Product Evaluation Program
NPV	Net Present Value
NPC	Net Present Cost
OSHA	Occupational Safety and Health Administration
P2	Pollution Prevention
POC	Point of Contact
PWL	Paint with Lead
SBIR	Small Business Innovative Research
SCAQMD	Southern California Air Quality Management District
SF	Square Feet
SSPC	The Society for Protective Coatings
TCLP	Toxicity Characteristic Leaching Procedure

TOC	Total Ownership Cost
VOC	Volatile Organic Compound
UFGS	Unified Facilities Guide Specification
UST	Underground Storage Tank
ZVT	Zero-VOC Topcoat

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ABSTRACT

A demonstration project was initiated to assess a newly developed coating system for steel above ground storage tanks (AST). The new system requires only two coats instead of the three coats of currently available systems. In addition, the new system greatly reduces volatile organic compounds (VOCs) thus meeting new California air quality requirements. Specifically, it is a 99% solids, sprayable, high build, low VOC, two-component, proprietary blend of Bis F epoxy and liquid polysulfide. The system was successfully applied on two AST in San Pedro, CA at a cost of $97,385. For comparison, the estimated cost of a standard 3-coat system applied over the same area is $125,000. The new system met all application requirements and field test performance requirements after one year of service. Cost analyses show that if the new system lasts 6 years it will be equal in life cycle cost with 3-coat systems which typically last 8 years. If the new system lasts eight years then there would be significant savings. Additional field tests are required after four and eight years of service to assure the new coating system meets long term performance requirements. At that point, a new Unified Facilities Guide Specification (UFGS) for maintenance painting of AST exterior surfaces will be established.

1. Introduction

1.1 Background

Corrosion of above ground storage tank (AST) steel exterior surfaces is a perennial and costly problem. To protect against corrosion, AST exterior surfaces typically receive a three-coat system consisting of

- a zinc rich epoxy primer (Military Detail Standard, MIL-DTL-24441, Formula 159, Type III),
- an epoxy intermediate (MIL-DTL-24441, Formula 152, Type IV), and
- a polyurethane topcoat (Military Performance Standard, MIL-PRF-85285D, Type II).

These are commonly formulated with about 304 g/l (2.5 lbs/gal), 340 g/l (2.8 lbs/gal) and 340 g/l (2.8 lbs/gal) of Volatile Organic Compounds (VOC's), respectively. Exterior AST maintenance painting is often required at around eight years service but the original three-coat system above is not appropriate for use over aged and weathered coatings. When the original system has been used as an overcoat system it has contributed to costly premature coating failures. These overcoat failures typically occur as a result of high levels of residual cure stress (curing of the overcoat system) combined with the daily thermal cycling (daily temperature extremes). Therefore, typical maintenance coatings currently require full removal of the existing coating and a reapplication.

In effect since August 2002, California's South Coast Air Quality Management District (SCAQMD) requires all Architectural and Industrial Maintenance (AIM) Coatings to contain no more than 250 g/l of VOCs and, effective August 2006, no more than 100 g/l of VOCs. A solution to the environmental problem of using a high VOC AIM coating system is to employ a system consisting of the recent Small Business Innovative Research (SBIR) developed Low VOC Barrier Coating (LVBC), for use as both the spot primer and intermediate coat, followed by the Environmental Security Technology Certification Program (ESTCP) validated zero-VOC topcoat (ZVT).

According to the Navy's infrastructure database, the Navy owns more than 1,572 storage tanks with a total replacement value of $2.98 billion. This includes 803 water storage, 68 ship fuel storage, 19 aviation gas storage, 412 diesel fuel storage, and 270 jet engine fuel storage tanks. AST maintenance painting using the LVBC/ZVT system could reduce annual Department of Defense (DOD) VOC emissions by as much as 22,750 lbs as well as produce annual saving in excess of $1.5M when compared to complete coating removal and reapplication.

1.2 Objectives of the Demonstration

This demonstration provides a full-scale validation of the LVBC for use as an AIM Coating, assists in the transition of a non-aircraft topcoating using the ZVT (MIL-PRF-85285D, Type III, Class W), and enables the transition of this very low VOC AIM Coating system directly into the hands of DOD end users who require AST maintenance painting.

The demonstration was conducted in Southern California at the Defense Energy Support Center (DESC), San Pedro, California. Two AST, originally coated in 1987 and located on the waterfront, were recoated with the LVBC/ZVT system. One AST was completely recoated on the top and sides for a total of about 10,500 square feet (SF) of exterior surface area. The other was coated on the roof only (2,850 SF). The demonstration consisted of

- A determination of coating assessment parameters,
- Examination of the selected tank's exterior coating system to assure it meets overcoat requirements,
- surface preparation,
- application of the LVBC followed by the ZVT, and
- documentation of established coating application parameters.

The resulting demonstration coating was monitored after one year of service in accordance with coating assessment parameters described herein. Additional coating assessments after four and eight years of service are required for an adequate assessment of the technology.

Demonstration results will be used to develop commercial guidance such as a new Master Painters Institute (MPI) Detailed Performance Standard (DPS) for the LVBC and a new Unified Facilities Guide Specification (UFGS) entitled "Maintenance Painting of Aboveground Storage Tank (AST) Exterior Surfaces." A draft of the UFGS document is provided as Appendix A. The MPI DPS and the UFGS will be web-displayed at http://www.paintinfo.com , and http://www.ccb.org/ufgs/ufgs.htm , respectively. These documents will be available for direct use by Tri-service activities with AST in need of maintenance painting. In addition, results will be posted at the Joint Service Pollution Prevention (P2) Library and presented at the Tri-service Environmental Centers' Coordinating Committee meeting, if applicable.

1.3 Regulatory Drivers

The project addresses the following requirements:

● Navy 3.1.04.a	Shipboard Paint and Coating Systems
● Air Force Need 805	Nonchromated, Volatile Organic Compound (VOC) Compliant Corrosion-Protective Coating System
● Air Force Need 944	Low-VOC Coating Formulations
● Army A (3.2.j/2.1.h)	Sustainable Painting Operations for the Total Army

Federal, state and local environmental agencies such as the Environmental Protection Agency (EPA) and California Air Quality Management Districts (AQMD) classify many VOC's as hazardous and restrict their emissions through regulations such as the Clean Air Act, as well as local EPA and AQMD rules. CNO directives require significant reductions in the amount of hazardous waste generated by the Navy. This technology will satisfy all of the above requirements because the AZT contains less than 5 g/l of VOC and the resulting cured paint contains no hazardous materials. Furthermore, the zero-VOC topcoat was developed from novel resin chemistry to be applied using conventional or high-volume-low-pressure (HVLP) application equipment.

1.4 Stakeholder/End-User Issues

Both the Army and Air Force exclusively employ a Navy developed Unified Facilities Guide Specification (UFGS) entitled UFGS - 09 97 13.27 “Exterior Coating of Steel Structures” for coating the exterior surfaces of either new AST or complete removal/reapplication of previously coated AST. The Army and Air Force rely heavily upon Navy developed criteria for use in all AST coating applications. A successful AST demonstration/validation of an AIM Coating system based on the LVBC/zero-VOC topcoat followed by the availability of new UFGS and MPI guidance documents for these products will lay the ground work for wide acceptance of this technology.

2. Technology Description

The first liquid polysulfide polymer became commercially available in 1943, thirteen years after the Thiokol Corporation developed and marketed a millable gum polysulfide known as the first synthetic rubber commercially made in the United States. Today, there are several liquid polysulfide polymers, each with distinctly different properties, but similar in chemical structure. To a large extent, products made from liquid polysulfide polymers have the same excellent overall solvent resistance properties as the millable gum polysulfides. However, the liquid polysulfides have the advantage of being room temperature vulcanized, meaning they can be cured at ambient temperatures after the addition of an oxygen donating curing agent (Figure 1).

$$HS(C_2H_4OCH_2OC_2H_4SH)_6C_2\ H_4OCH_20C_2H_4SH$$

FIGURE 1. Disulfide Linkages (Thiol Terminal Groups: -SH).

Liquid polysulfide polymers are classified as high-quality, application-proven products that can be compounded as sealants, adhesives, coating, potting compounds and flexible molding compositions, as well as used for impregnating leather and other porous materials. Compounds based on these polymers are used in industrial and building construction, insulation, glass, aerospace, electronics, aviation, marine and many other industries.

The manufacturing process for liquid polysulfide polymers follows the general method of chemical preparation whereby an organic dihalide is reacted with sodium polysulfide at elevated temperatures. A controlled amount of a trifunctional organic halide, which serves to introduce cross-linking sites, is co-reacted in the process. These cross-linking sites permit a range of elongation and modulus properties of the cures polymer.

Epoxy resins date back to about 1949. Their many excellent properties include rapid curing at normal temperatures, good adhesion to most surfaces, toughness and chemical resistance to most

dilute acids, alkalis and solvents. Early uses included heavy-duty industrial paints and structural adhesives in the aircraft industry.

Today, epoxy resin compounds are widely used in construction, marine, electrical and industrial markets. However, in order to meet the different physical properties required for these various markets, certain characteristics of the early epoxy systems have been changed. To “flexibilize” an epoxy, a liquid polysulfide polymer is added. The polysulfide improves certain physical properties without adversely affecting the existing performance capabilities of the epoxy resin.

Versatile systems are possible by co-reacting polysulfides with epoxy resins (Figure 2). These systems exhibit the toughness and adhesion of epoxy plus show the improved impact and general chemical resistance of polysulfide.

$$\begin{array}{l} \quad\;\; \mathbf{O} \qquad\qquad\qquad\qquad\qquad\qquad\quad\;\; \mathbf{O} \\ \quad\; / \;\; \backslash \qquad\qquad\qquad\qquad\qquad\qquad\;\; / \;\; \backslash \\ \mathbf{\text{-R-CH-CH}_2 + \text{HS-R'-SH} + \text{H}_2\text{C-CH-R}} \end{array}$$

$$\begin{array}{l} \qquad \mathbf{OH} \qquad\qquad\qquad\qquad\quad \mathbf{OH} \\ \qquad\; | \qquad\qquad\qquad\qquad\qquad\;\; | \\ \mathbf{\text{-R-CH-CH}_2\text{-S-R'-S-CH}_2\text{-CH-R}} \end{array}$$

FIGURE 2. Co-Reaction of Polysulfides with Epoxy Resins.

Three different epoxy resins can be used with polysulfides:

- Bisphenol A,
- Bisphenol F, and
- Novolac.

Each epoxy resin has its own special attributes as follows:

Bisphenol A- low cost, low viscosity, high epoxide content liquid resin ideal for coatings, adhesives, casting, potting, encapsulation, and wet lay- up applications.

Bisphenol F- more expensive, lower viscosity than A, and improved chemical resistance. It is more resistant to inorganic acids than bisphenol A.

Novolac- a high viscosity semisolid to solid resins with multiple functional groups, with increased cross-link density, better physical properties at elevated temperatures, and improved solvent and chemical resistance compared to bisphenol A and F.

2.1 Technology Development and Application

The technology demonstrated was developed in response to the Small Business Innovative Research (SBIR) Program's Solicitation 01.1, "N0-027: Sprayable Polysulfide Elastomeric Development." Prior to this work, neither the Government nor Industry had developed a viable environmentally compliant barrier coating for use in overcoating marginally sound coating systems previously applied to exterior AST. The SBIR objective was to develop a reduced VOC, high solids, environmentally compliant, elastomeric, sprayable, polysulfide-based barrier coating with low residual cure stress, low hygrothermal stress, sustainable flexibility, high corrosion resistance (hydrolytic stability), resistance to weathering, moderate tensile strength, sound adhesion, and good chemical compatibility when applied over industrial topcoats. Quantitatively, the SBIR coating was to meet or exceed the following requirements:

- ≥ 95% volume solids,
- 140% to 450% elongation,
- Hydrolytic stability (pH 3 to pH 13.5, resistant to cathodic protection),
- 200 psi to 400 psi tensile strength,
- 45°F to 95°F application and curing temperature,
- Internally plasticized,
- < 70 psi combined residual cure stress and hygrothermal stress throughout service temperatures and humidity,
- < 1.0×10^{-8} cm/sec water permeability,
- 180 psi to 400 psi adhesion to previously applied coatings,
- Chemically compatible with vinyl, urethane, acrylic, epoxy, and alkyd coatings,
- Topcoatable, sprayable, and environmentally compliant.

Under this SBIR contract, PolySpec L.P. (the Contractor), developed a 99 % solids, sprayable, high build, low VOC, two-component, proprietary blend of Bis F epoxy and liquid polysulfide which displayed maximum adhesion to industrial topcoats, good tensile strength, outstanding flexibility, and very good barrier protection. This low VOC formulation is now virtually free of Hazardous Air Pollutants (HAP).

2.2 Previous Testing of the Technology

The LVBC was developed and tested in the laboratory under Phase I and Phase II SBIR efforts as performed by PolySpec L.P., including plural component spray trials (Refs. 1 and 2). Preliminary results indicate formulation, physical and laboratory performance properties exceed Navy requirements.

With support from the Naval Facilities Engineering Command (NAVFAC), the Naval Facilities Engineering Service Center (NFESC) conducted a 1300 SF field demonstration on a severely deteriorated coating system over galvanized sheet metal located on the California waterfront (Figures 3 and 4). The deteriorated coating system was prepared using high pressure water blasting and the LVBC was plural component spray applied at 7 – 10 mils followed by a topcoat

of water-based acrylic. The entire structure was coated in less than one day without any difficulties and displayed very good substrate and intercoat adhesion of more than 200 psi. At 1.1 years service, all non-angular surfaces were provided excellent protection (Ref. 3). Recent observations (April 2007) indicate the coating is still in very good condition.

FIGURE 3. Building 1325, Naval Base Ventura County Before LVBC Coating.

FIGURE 4. Building 1325 After Coating.

2.3 Factors Affecting Cost and Performance

The primary factors affecting and potential cost increases will not be the LVBC/AZT system price per gallon but rather in the costs associated with the following anticipated coating operations:

- surface preparation (high pressure water blasting),
- wastewater/paint debris containment, collection/treatment/disposal
- high pressure water cleaning equipment,
- plural component paint application equipment,
- surface preparation, and
- application equipment rental or procurement for small scale coating work,

The principal factors that could negatively affecting LVBC performance and thus its life cycle costs may include:

- LVBC/ZVT applied by contractors not certified to industry standards such as those provided by the Society for Protective Coatings (SSPC), and
- LVBC and ZVT each supplied by individual vendors with two separate and potentially conflicting performance warranties.

These factors are analyzed in Sections 4 and 5 of this report based on data gathered before, during, and after application of the demonstration project coating.

2.4 Advantages and Limitations of the Technology

The main advantages of the LVBC/AZT system are:

- Compliant with current/future AIM Coating VOC requirements for EPA, State, District and Regional Counties.
- Elimination of environmental fines associated with AIM Coating VOC regulations.
- Reduced coating removal collection/treatment/disposal costs.
- Reduced facility Total Ownerships Costs (TOCs).
- Rapid AST coating maintenance.
- Enhanced AST corrosion control.
- Flexible, corrosion resistant barrier coating with low residual cure stress.
- Maximum adhesion to a variety of topcoats.

The main limitations of the LVBC/AZT system are:

- Requires industry/coating manufacturer certified coating contractor.
- May require specialized surface preparation/application equipment.
- Conflicting warranties created by separate LVBC and ZVT manufacturers.
- Single LVBC supplier may require sole source or performance based DOD procurement.
- Coating Condition Survey (CCS) required for quantifying acceptable overcoating risk.

As quoted in a January 2003 Army publication (Ref. 4), “Industry standards for overcoating do not exist,” and trade journal articles such as “Overcoating Lead-Based Paint on Bridges: An Overview of Different Coating Options” (Ref. 5) continue to provide valuable information detailing AIM Coating but without providing concrete industry guidance. Overcoating paints and materials such as acrylic latex, calcium sulfonated alkyd, epoxy, conventional oil/alkyd, polyurethane, moisture-cured urethanes, waxes, and tapes have been employed for maintenance painting with variable performance and non-uniform environmental compliance.

3. Demonstration Design

3.1 Performance Objectives

Table 3-1 provides primary “Performance Objectives” for the LVBC/ZVT and lists primary performance criteria, expected performance metric, and actual performance objective met (future). In addition to primary performance objectives, secondary performance objectives are presented in Section 4 “Performance Assessment,” Table 4-1 “Performance Criteria,” below. Performance objectives are further defined and confirmed employing performance criteria, expected performance metric, and performance confirmation methods, as presented in Table 4-2 “Expected Performance and Performance Confirmation Methods.” These tables are taken from the demonstration plan that was approved by ESTCP in January 2004.

TABLE 3-1. Performance Objectives.

Type of Performance Objective	Primary Performance Criteria	Expected Performance Metric
Quantitative	1) Condition of demonstration site coating system for corrosion, peeling, blistering, tape adhesion, pull-off adhesion, film thickness, and LVBC/ZVT patch test adhesion. 2) Reduced VOC emissions. 3) Reduced hazardous materials. 4) Reduced painting operations debris/waste. 5) One-year and four years field performance for corrosion, peeling, blistering, tape adhesion, pull-off adhesion, film thickness, cracking/checking, chalking, biological growth, and dirt pick-up.	1) Meet minimum pre-demonstration coating system criteria as defined in Table 4.2. 2) VOC emissions reduced by 95%. 3) Reduced LVBC/ZVT formulation hazardous materials by 95% . 4) Collection/disposal wastes reduced by 25%. 5) Meet individual field performance criteria as defined in Table 4-2.
Qualitative	1) Pre-demonstration coating condition survey for substrate condition, primer classified, midcoat classified, topcoat classified, LVBC/ZVT patch test, salt contamination, and presence Lead/Chromium.	1) Meet minimum pre-demonstration coating condition survey as defined in Table 4.2.

3.2 Selecting Test Platforms/Facilities

California SCAQMD's low VOC requirements for all AIM Coatings represent the country's most stringent standards. Therefore, thirteen DOD sites within California with AST in need of maintenance painting were visually assessed for a potential project demonstration.

The representative DOD site selected is located in Southern California at the Defense Energy Support Center (DESC), San Pedro. The site is located at the entrance to the Port of Long Beach and is less than 2,000 feet from the ocean (Figures 5 and 6). The LVBC/ZVT maintenance painting demonstration was performed on the exterior of two 10,500 SF AST (846K gallons each) originally coated in 1987 (Figures 7 and 8). DESC personnel, PolySpec L.P., and the DOD technical point of contacts (POC's) were involved in performing and assisting with the demonstration at the DESC site.

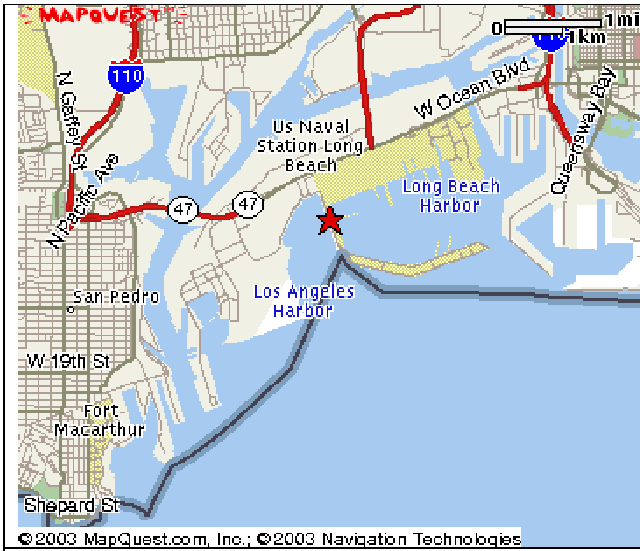

FIGURE 5. Map of Demonstration Site.

FIGURE 6. Aerial View of Site.

FIGURE 7. DESC Demonstration Site, Long Beach, CA.

FIGURE 8. View from the top of Tank 2001.

3.3 Test Platform/Facility History/Characteristics

DESC San Pedro (Americas West) manages bulk fuel and additives distribution to 11 western states, including support to DESC-Pacific locations in Alaska, Hawaii and the Pacific Rim. Operations at San Pedro primarily involve off-loading tanker fuel, pumping fuel to bulk holding AST/Underground Storage Tanks (UST), followed by underground pipe or truck distribution to DOD activities requiring fuel. The site is subjected to moderate marine exposure, heavy industrial pollution such as acidic fog and dew, and significant UV exposure.

3.4 Present Operations

DESC San Pedro exterior AST coating operations generally involve initial coating application using guidance similar to UFGS 09 97 13.27 “Exterior Coating of Steel Structures” followed by either allowing the coating system to fail and then completely removing and reapplying in accordance with UFGS 09 97 13.27 or by performing short term unsuccessful spot maintenance painting. When complete removal and reapplication in accordance with UFGS 09 97 13.27 is compared to maintenance painting employing the LVBC/ZVT, the major cost differences appear to be:

- Labor intensive complete removal of existing coating,
- Excessive quantities of spent abrasive blast media/paint debris for disposal,
- Full AST containment during surface preparation,
- Complete reapplication of a three-coat system,
- Potential lengthy AST down time, and
- Higher Cost Per Unit Area (CPUA) to install.

3.5 Pre-Demonstration Testing and Analysis

Section 2.1 “Technology Development and Application” and Section 2.2 “Previous Testing of the Technology” describe the pre-demonstration testing and analysis of the LVBC. This report provides the first detailed analysis of the LVBC/AZT system.

3.6 Testing and Evaluation Plan

The following is a brief summary of the completed demonstration plan that was approved January 2004.

3.6.1 Demonstration Set-Up and Start-Up

The format and general content of UFGS 09 97 13.27 “Exterior Coating of Steel Structures” provided the basis for the demonstration set-up and start-up including requirements for site preparation and utilities for a full-scale demonstration. UFGS 09 97 13.27 was modified as necessary for the full-scale LVBC/ZVT demonstration and subsequently used as the primary installation contract specification for the demonstration work. In addition, the modified UFGS 09 97 13.27 specification included a “Quality Control Plan” (Appendix B) as well as a “Health and Safety Plan.”

3.6.2 Period of Operation

The initial evaluation of the LVBC/ZVT coating system test patch was completed in Oct 2003. The full-scale demonstration coating was applied in about a 3-week period in March 2004. The first year field performance evaluation was completed in March 2005. Concurrent laboratory product analysis (panel testing) was initiated in Dec 2003 with the data released in January 2006.

3.6.3 Amount/Treatment Rate of Material to be Treated

Approximately 13,350 SF of a 17 year-old aged and weathered exterior coating system (two AST) received the LVBC/ZVT maintenance painting system.

3.6.4 Residuals Handling

A waste management plan was required by the contract in accordance with UFGS 01 77 00.00 20 “Closeout Procedures” guidelines.

3.6.5 Operating Parameters for the Technology

Standard daily coating field operation parameters were monitored and recorded to include but not limited to the following:

- Air temperatures,
- Substrate temperatures,
- Dew point,
- Relative humidity,
- Surface preparation and installation equipment operating parameters, and
- Resulting level of surface preparation.

Surface preparation operations included a combination of water blasting and abrasive pads. The LVBC and ZVT were applied employing commmercial off-the-shelf (COTS) equipment featuring high-pressure, high-volume airless spray with heated delivery hoses and heated mixing pots. Industry standards such as those provided by the SSPC were followed in accordance with detailed contract requirements.

3.6.6 Experimental Design

The primary LVBC/ZVT demonstration events followed for each of the two AST are sequentially listed as follows:

- Pre-demonstration assessment employing a coating condition survey,
- Field application of LVBC/ZVT patch test,
- Quantitative assessment of LVBC/ZVT patch test,
- No more than 3.0 % removal of existing AST coating system during LVBC/ZVT surface preparation,
- Containment, collection, and proper disposal of any and all surface preparation waste,
- Installation of LVBC/ZVT as a 100 % maintenance overcoat,
- Documentation of demonstration parameters, and
- One year LVBC/ZVT field performance monitoring and assessment reporting.
- Year four field performance assessment if resources are available to do so.

Detailed coating application procedures are presented in the LVBC/ZVT demonstration contract which is available upon request. Analytical testing and data collection methods used in this demonstration project are a combination of requirements set by industry standards (Appendix C) modified by the American Association of State Highway and Transportation Officials (AASHTO) product testing requirements (AASHTO R 31-02: Standard Practice for Evaluation of Coating Systems with Zinc-Rich Primers). The demonstration project experimental design plan includes the demonstration performance objectives, performance criteria, and expected performance metrics. These are shown in Tables 3-1, 4-1, and 4-2, respectively.

Two noteworthy pre-demonstration conditions that had to be satisfied prior to the full scale demonstration are listed in Table 4-2 under "Primary Criteria:" These are:

- Pull-off adhesion of more than 110 psi (existing coating system), and
- LVBC/ZVT patch test adhesion of more than 110 psi supported by a tape test adhesion rating of 2A.

The underlying assumption is that the low-stress (flexible) LVBC/ZVT when newly applied and throughout its service life will not generate a combination of stress (e.g., residual curing stress, thermal cycling stress, hygrothermal stress, differences in coefficient of thermal expansion) that exceeds the work of the existing coating system's adhesion of 110 psi. In general, overcoating failures have been observed when high-stress, industrial maintenance coating systems have been applied to aged and weathered coatings with substrate and/or intercoat adhesion of less than 110 psi.

The year one LVBC/ZVT field performance monitoring and assessment reporting was performed in accordance with "Primary Criteria" as presented in Table 4-2.

3.6.7 Demobilization

Following the completion of the full-scale demonstration, the coating contractor restored existing facilities in and around the work areas to their original conditions, including the removal of debris, equipment, materials, temporary connections to Government or Contractor furnished water and electrical services. UFGS-01770N "Closeout Procedures" provided guidelines as part of the contract for equipment demobilization.

3.6.8 Health and Safety Plan

Section 01525 "Safety And Occupational Health Requirements" and Section 13283N "Removal /Control And Disposal Of Paint With Lead" of the demonstration contract form the demonstration site "Health and Safety Plan." To ensure additional "Health and Safety Plan" compliance, the Industrial Painting Contractor was required to be certified by the Society for Protective Coatings (SSPC) to:

- SSPC QP-2 "Standard Procedure for Evaluating the Qualifications of Painting Contractors to Remove Hazardous Paint," and

- SSPC QP-1 “Standard Procedure for Evaluating the Qualifications of Painting Contractors Performing Industrial Surface Preparation and Coating Application in the Field.”

3.7 Selection of Analytical/Testing Methods (Product Testing)

Refer to Table 4 – 2 “Expected Performance and Performance Confirmation Methods” for primary and secondary testing methods, expected performance metrics, and the individual standards for use as performance confirmation.

In addition to the field demonstration assessments, laboratory testing of the LVBC/AZT system was completed. PolySpec L.P.’s sponsored laboratory testing of the LVBC/AZT system was performed by the American Association of State Highway & Transportation Official’s (AASHTO) National Transportation Production Evaluation Program (NTPEP) for “Structural Steel Coating Systems.” The tests employed AASHTO Standard Practice R 31-02 and consisted of the quantitative secondary performance criteria as defined in Table 4 – 2.

A combination of laboratory and field performance data is mandatory since laboratory testing seldom reflects field performance and field performance rarely duplicates accelerated laboratory weathering. The NTPEP product testing data will support full-scale field demonstration data and provide additional LVBC/AZT data for use in baseline comparisons with alternative systems.

3.8 Selection of Analytical/Testing Laboratory

PolySpec L.P.’s sponsored laboratory testing of the LVBC under AASHTO’s NTPEP program was performed by Corrosion Control Consultants and Labs, Inc. of Grand Rapids, MI, a certified AASHTO-Select Test Facilities. Under the completed SBIR effort, PolySpec L.P. employed The Coatings Laboratory of Houston, TX to assist in quantifying LVBC formulation and physical properties.

4. Performance Assessment

4.1 Performance Criteria

Table 4-1 presents general “Performance Criteria” for the LVBC/ZVT and includes criteria for Field Performance, Pre-Demonstration, Product Testing, Hazardous Materials, Process Waste, Factors Affecting Technology Performance, Reliability, Ease of Use, Versatility, Maintenance, and Scale-Up Constraints.

TABLE 4-1. Performance Criteria.

Performance Criteria	Description	Primary or Secondary
Pre-Demonstration ●Condition of Demonstration Site Coating System	Must meet minimum pre-demonstration coating system criteria as defined by ASTM standards and individually presented in Table 4.2 for the following: - Coating Type - Corrosion - Peeling - Blistering - Tape Adhesion - Pull-Off Adhesion - Film Thickness - LVBC/ZVT Patch Test Adhesion	Primary
Product Testing ●Formula ●Laboratory Performance	PolySpec L.P. testing, under AASHTO's NTPEP program, will be performed concurrently with the demonstration; results of formula, laboratory performance, and field performance testing will be correlated to demonstration performance for use in developing specification standards for the LVBC. Individual ASTM standards for the NTPEP testing are presented in Table 4.2 and include testing for: - Color - VOC - Total Solids (wt) - Total Solids (volume) - Percent Pigment - Stormer Viscosity - Brookfield Viscosity - Pot Life - Sag Resistance - Theoretical Coverage - Drying Times - Mixing Ratio - Shelf Life - Infrared Analysis - Heavy Metals - Dry Film Leachable Metals - Epoxide Value - Amine Value - 4,000 hrs Salt Fog Resistance - 336 hrs Cyclic Weathering - Abrasion Resistance - Adhesion Testing - 30 Day Freeze Thaw Stability - 2 Years Atmospheric Exposure	Secondary

Field Performance ● At One Year and Four Years	Must meet minimum field performance criteria as defined by ASTM standards and individually presented in Table 4.2 for the following: - Corrosion - Peeling - Blistering - Tape Adhesion - Pull-Off Adhesion - Film Thickness - Cracking/Checking - Chalking - Biological Growth - Dirt Pick-Up	Primary
Process Waste	The cured LVBC/ZVT composite film does not appear to contain hazardous material (HAZMAT) and cured coating waste could be disposed of as non-hazardous waste, pending further analysis.	Primary
Factors Affecting Technology Performance	The new technology was developed for use with a Commercial-Off-The-Shelf (COTS) plural component spray rig: however, special operator skill throughout spraying is required to ensure controlled mixing/uniform application and two spray equipment operators are required during use.	Secondary
Reliability	Reliability should be higher than routine maintenance painting employing traditional coating materials.	Secondary
Ease Of Use	Equal level of contractor competence is required as minimum qualifications for LVBC/ZVT installation. The Society for Protective Coatings (SSPC) QP-1 contractor certification is required.	Secondary
Versatility	The technology will be used for maintenance painting of the coating system specified in UFGS 09 97 13.27 "Exterior Coating of Steel Structures." In addition to protecting steel surfaces, PolySpec L.P plans to transition the technology for use in protecting concrete surfaces.	Secondary
Maintenance	Maintenance of the LVBC/ZVT should require a level of maintenance less than routine corrosion prevention on AST due to enhanced barrier protection.	Secondary
Scale-Up Constraints	The demonstration will be performed at full-scale using COTS surface preparation and LVBC/ZVT application equipments.	Secondary

4.2 Performance Confirmation Methods

In addition to the reduction of VOC emissions and overall environmental compliance, a successful LVBC/ZVT maintenance painting application was determined after one year of field performance. Long-term performance will be assessed after four and eight years of service. Table 4-2 "Expected Performance and Performance Confirmation Methods" quantitatively

defines acceptable one-year and four years field performance metrics for evaluating the listed criteria.

The demonstration was conducted in accordance with Appendix B "Data Quality Assurance/ Quality Control Plan" for laboratory testing, LVBC/ZVT coating application, and field tests and inspections.

Table 4 – 2. Expect Performance Metrics and Confirmation Methods.

Performance Criteria	Expected Performance Metric	Performance Confirmation Method
PRIMARY CRITERIA (Performance Objectives) (Quantitative)		
Pre-Demonstration		
● Coating Condition Survey		
- Corrosion	No more than 15% corrosion	ASTM D 610 (% of total surface area)
- Peeling	No more than 15% peeling	ASTM D 610 (% of total surface area)
- Blistering	No more than 15% blistering	ASTM D 610 (% of total surface area)
- Tape Adhesion	No less than 2A	ASTM D 3359 (> 3 tests)
- Pull-Off Adhesion	More than 110 psi	ASTM D 4541 (> 3 tests)
- Film Thickness	No more than 20 mils	ASTM D 4138, SSPC PA-2 (> 3 tests)
- Substrate Condition	No Visible Underfilm Corrosion	Visual, 10X Microscope
- Primer, Midcoat, Topcoat	Coatings Identified	FTIR, ASTM D 2621 (1 test)
- Salt Contamination	Document Values	Field Kit
- Lead/Chromium	Document Values	ASTM D 3335, ASTM D 3718 (3 tests)
- LVBC/ZVT Patch Test	More than 110 psi and > 2A	ASTM D 3359, D 4541 (3 tests)
Demonstration Application		
● VOCs Discharged		
- LVBC	VOC emissions reduced by 95%	Quantitative comparison to MIL-DTL-24441/31A
- ZVT	VOC emissions reduced by 95%	Quantitative comparison to MIL-PRF-85285D, Type II
● Total Debris/Waste Generated		
- Surface Preparation	Water/debris collection/disposal reduced by 25 %	Quantitative Operation Comp.
- Painting	Debris collection/disposal reduced by 25 %	Quantitative Operation Comp.
One and Four-Year Field Performance		
- Corrosion	No more than 0.1 % corrosion	ASTM D 610 (% of total surface area)
- Peeling	No more than 0.1 % peeling	ASTM D 610 (% of total surface area)
- Blistering	No more than 0.1 % blistering	ASTM D 610 (% of total surface area)
- Tape Adhesion	No less than 3A	ASTM D 3359 (> 3 tests)
- Pull-Off Adhesion	More than 110 psi	ASTM D 4541 (> 3 tests)
- Film Thickness	Report Thickness	ASTM D 4138, SSPC PA-2 (>> 3 tests)
- Cracking/Checking	No less than 8	ASTM D 660, ASTM D 661 (% of area)
- Chalking	No less than 8	ASTM D 4214 (% of total surface area)
- Biological Growth	No less than 8	ASTM D 3274 (% of total surface area)
- Dirt Pick-Up	No less than 8	ASTM D 3274 (% of total surface area)

NTPEP LVBC Testing (R 31-02)		
●Formula		
- Color	Property Documented	Fed. Std. 595, ASTM D 2244
- VOC	No more than 50 g/l	ASTM D 2369
- Total Solids (wt)	Property Documented	ASTM D 2369
- Total Solids (volume)	Property Documented	ASTM D 2697
- Percent Pigment	Property Documented	ASTM D 2371
- Stormer Viscosity	Property Documented	ASTM D 562
- Brookfield Viscosity	Property Documented	ASTM D 2196
- Pot Life	Property Documented	N/A
- Sag Resistance	No less than 7 mils	ASTM D 4400
- Theoretical Coverage	Property Documented	N/A
- Drying Times	Properties Documented	ASTM D 1640
- Mixing Ratio	Property Documented	N/A
- Shelf Life	Property Documented	N/A
- Infrared Analysis	LVBC Fingerprint	N/A
- Heavy Metals	Free of Chromium, Lead, Cadmium	ASTM D 3335, ASTM D 3718
- Dry Film Leachable Metals	Free of Arsenic, Mercury, Silver	TCLP/EPA SW 846
- Epoxide Value	Property Documented	ASTM D 1652
- Amine Value	Property Documented	ASTM D 2073
●Laboratory Performance		
- 4,000 hrs Salt Fog Resistance	Performance Documented	ASTM B 117, ASTM D 1654
- 336 hrs Cyclic Weathering	Performance Documented	ASTM D 5894
- Abrasion Resistance	Values Documented	ASTM D 4060
- Adhesion Testing	Performance Documented	ASTM D 4541
- 30 Day Freeze Thaw		AASHTO R 31-02
●Atmospheric Testing		
- 2 Years Exposure	Performance Documented	Severe Marine Exposure, Quantitative Panel Evaluation
SECONDARY PERFORMANCE CRITERIA (Qualitative)		
Ease of Use	Contractor Friendly	Operator experience

4.3 Data Analysis, Interpretation and Evaluation

4.3.1 Pre-Demonstration Test Results:

The pre-demonstration test data strongly indicated that the tank surfaces would be excellent candidates for the LVBC/AZT overcoat demonstration project. The tests were initiated in October 2003.

Observations of corrosion products, peeling, and blistering indicated all were less than established limits of 0.3% on the walls and sides of both AST 2001 and 2003. There was no visible underfilm corrosion. The preexisting coatings on Tanks 2001 and 2003 were sampled on the roof and walls for coating thickness analyses. Averaged results were 5 and 7 mils dry film

thickness (DFT) on the sides and roof of Tank 2001, respectively. On Tank 2003, average results were 4 and 5 mils on the sides and roof, respectively. These are well within the 20 mil limit.

Tanks 2001 and 2003 roof surface salt (chlorides) contamination testing (3 samples each) showed minimal results (<1.5 ppm and 2.5 ppm, respectively). Water effluent chloride concentration at Tank 2003 was determined to be 70 ppm. These results indicate little concern for salt contamination affecting coating performance.

Original paint samples were taken from both AST to determine paint types in order to assure compatibility with the planned maintenance overcoat system. The paint samples were analyzed by Fourier Transform Infrared Spectroscopy (FTIR) to determine organic constituents. The analysis showed that both tanks have an alkyd or other ester-based based primer and an alkyd top coat. Metals analyses of these samples showed that the preexisting coatings have relatively high chromium content – 76,700 and 70,700 mg/kg in tanks 2001 and 2003, respectively. Lead content was 1200 and 1300 mg/kg, respectively. The chromium is likely from a yellow chromate primer. Lead pigments are common. The preexisting coating on both tanks were apparently from the same system and likely conform to UFGS 09 97 13.27. This makes it compatible with an LVBC/AZT overcoat.

Test LVBC/AZT overcoat patches were applied to tanks 2001 and 2003 (Figure 9). After seven days of cure, tape and pull off adhesion tests were conducted; three each on the roofs and sides of each tank and the test patches. Adhesion test results of overcoat patches as well as existing coatings (Figure 10) were within the limits established in Table 4-2; i.e., no less than 2A for the tape adhesion tests and no less than 110 psi for the pull tests. One exception was one of three tape tests on the Tank 2003 LVBC/AZT test patch which was 1A. However, the three pull test results on this patch were all 110 psi or greater.

FIGURE 9. LVBC/AZT Test Patch.

FIGURE 10. Adhesion Pull Test on Original Coating.

4.3.2 Demonstration Application Performance and Ease of Use:

Surfaces were prepared for overcoating by abrasive scrubbing followed by low pressure water cleaning at 3,000 to 4,000 psi (Figures 11 and 12). This resulted in about 3 to 4% top coat removal on the roofs but less than 1% on the walls. Water and debris were collected and removed in accordance with contract requirements. A total of about 70 gallons of LVBC/AZT coating on Tank 2003 sides and roof was applied by an "airless" pressurized system with best results at about 2800 psi (Figure 13). About 25 gallons was applied by squeegees and rollers to the roof of Tank 2001 (Figure 14). The spray system provided better results. Some rework was required but overall job quality was acceptable. This was achieved despite the unique handling characteristics of the LVBC/AZT coating that required on-the-job learning by the paint contractor. This was primarily the need for carefully managed automatic mixing of components and water thinning of the AZT top coat.

FIGURE 11. Containment Plastic over Scaffolding on Tank 2003.

FIGURE 12. Surface Preparation by Water Blasting.

FIGURE 13. Spray application of LVBC Barrier Coating on Tank 2003 roof.

FIGURE 14. AZT Topcoat Applied by Rollers on Tank 2001 roof.

Pull and Tape Adhesion tests of the new coating, conducted several days after applications, indicated coating adhesion on tank 2001 roof of between 210 and 250 psi and 4A. Tests on tank 2003 roof and sides indicated adhesion between 190 to 230 psi and 5A. These results show good initial adhesion between the overcoat and the preexisting system – a condition vital to long-term performance. DFT samples (10 total) of Tank 2003 roof ranged from 9.5 to 20.7 mils while samples (50) taken from the sides ranged from 11.0 to 25.6. The tank 2001 roof samples (10) ranged from 13.2 to 21.8.

VOC reduction was not measured directly but instead calculated based on VOC content of the LVBC/AZT coating compared with standard coatings applied in accordance with MIL-DTL-24441/31A (for LVBC) and to MIL-PRF-85285D, Type II (for AZT). These standard coatings contain 304 g/l (2.5 lbs/gal) and 340 g/l (2.8 lbs/gal) of Volatile Organic Compounds (VOCs), respectively. Lab analysis of the coating system applied for this demonstration project (Table 4-3) showed a VOC content of 65.6 g/L for the LVBC primer and 2.6 g/l for the AZT top coat. Since approximately 95 gallons of coating was used (half of which was primer, the other half top coat), the total VOC's lost to the atmosphere was about 26.6 lbs. If a conventional coating was applied, it would take about 140 gallons and the total VOC's lost to the atmosphere would have been about 371 lbs. The difference between the two systems is over 300 lbs per application area equivalent to that of the demonstration project for a VOC reduction of approximately 93%.

A performance criterion measured during the demonstration application was the total debris/waste generated during surface preparation and painting (Table 4-2). Low pressure water cleaning was the principal means for surface preparation for this project since the existing coating did not have to be completely removed. About 3050 gallons of waste water was collected during the surface preparation of the sides and top of Tank 2003. Only 150 gallons of water was used for the roof of Tank 2001. Toxicity Characteristic Leaching Procedure (TCLP) analysis of the waste water showed no contamination that would bar routine disposal.
For the standard coating system, the existing coating would have had to be completely removed via abrasive blasting or waterjetting. This would have resulted in a much greater quantity of paint / abrasive media / waste water - debris possibly containing chromium and lead.

The waste solvent generated from cleaning operations such as for equipment is not included in the VOC analysis. Most of this type of waste is recovered and sent to a recycler to be recovered or reclaimed and reused. For example; 20 gallons of Methyl Ethyl Ketone (MEK) was used during this operation and 19.5 gallons was recovered as waste.

4.3.3 NTPEP Panel Testing (Secondary Criteria):

NTPEP testing included formula characteristics of the LVBC/AZT coating system as well as laboratory and field panel testing (Figures 15 and 16). Results of these analyses are presented in Appendix D and summarized in Table 4-3. Of special significance are the sag resistance, salt fog, and cyclic weathering tests. Both the LVBC and AZT coatings failed these tests. Since

these tests are predictors of long-term performance, it will be critical to track the actual long-term performance of the applied demonstration coatings.

FIGURE 15. Cyclic Weathering Test Sample of the LVBC/AZT System.

FIGURE 16. Adhesion Test Sample of the LVBC/AZT System.

Table 4 – 3. NTPEP PANEL Test Results Summary.

Performance Criteria	**Required Value** (NEPCOAT Criteria)	**Test Method**	**Test Results**
NTPEP Testing (R 31-02)			
● LVBC Formula			
- VOC	< 500 g/l	ASTM D 2369	**Pass** - 2.6 lbs/gal
- Total Solids (wt)	Value Documented	ASTM D 2369	71.0%
- Total Solids (volume)	Value Documented	ASTM D 2697	62.9%
- Pot Life	Value Documented	N/A	3 hrs
- Sag Resistance	No less than 7 mils	ASTM D 4400	**Fail** - 8.4 mils wft
- Dry Film Leachable Metals	None detectable	TCLP/EPA SW 846	**Pass** - None detected
● AZT Formula			
- VOC	<340 g/l	ASTM D 2369	**Pass** - 65.6 g/l
- Total Solids (wt)	Value Documented	ASTM D 2369	95.0%
- Total Solids (volume)	Value Documented	ASTM D 2697	90.9%
- Pot Life	Value Documented	N/A	15-20 mins.
- Sag Resistance	No less than 7 mils	ASTM D 4400	**Fail** - 26 mils wft
- Dry Film Leachable Metals	None detectable	TCLP/EPA SW 846	**Pass** - None detected
- Epoxide Value	Value Documented	ASTM D 1652	9800 grams
- Amine Value	Value Documented	ASTM D 2073	20.3 grams
● Laboratory Performance of LVBC/AZT system			
- Salt Fog Resistance	5,000 hrs - 4k creep max.	ASTM B 117, ASTM D 1654	4,000 hrs Pass **5,000 hrs Fail** – 6 to 15k max. creep values

- Cyclic Weathering	15 cycles – 8k creep max.	ASTM D 5894	**Fail** – 17 to 21 max. creep values
- Abrasion Resistance	Values Documented	ASTM D 4060	62.5 mg/cycle (avg.)
- Adhesion Testing	Values Documented	ASTM D 4541	4.4 MPa (avg)[1]
- 30 Day Freeze Thaw Stability	Values Documented	AASHTO R 31-02	3.2 MPa (avg)[1]
●Atmospheric Testing			
- 2 Years Exposure	Performance Documented	Severe Marine Exposure, Quantitative Panel Evaluation	**Two Year Data not found**

Note 1: 1 MPa = 145 psi

4.3.4 One-Year Field Performance:

Table 4-4 shows the results of coating evaluations conducted one year after coating applications. These data clearly show excellent performance after one year (Figures 17 and 18). Much longer exposure periods, however, are required to provide an accurate evaluation of the performance characteristics of this system. A four year field performance evaluation is planned.

Table 4 – 4. One Year Field Test Results Summary.

Performance Criteria	**Expected Performance Metric**	**Performance Confirmation Method**	**Actual Results**		
			2001 Roof	2003 Roof	2003 Sides
- Corrosion	No more than 0.1 %	ASTM D 610 (% of TSA[1])	0.03%	0.03%	0.03%
- Peeling	No more than 0.1 %	ASTM D 610 (% of TSA)	0.01%	0.01%	0.01%
- Blistering	No more than 0.1 %	ASTM D 610 (% of TSA)	0.01%	0.01%	0.01%
- Tape Adhesion	No less than 3A	ASTM D 3359 (> 3 tests)	5A	5A	5A
- Pull-Off Adhesion	More than 110 psi	ASTM D 4541 (> 3 tests)	290 psi	260 psi	240 psi
- Film Thickness	Report Thickness (DFT)	ASTM D 4138, SSPC PA-2 (> 3 tests)	12.7- 24.8	11.5- 22	13- 19.6
- Cracking/Checking	No less than 8	ASTM D 660, ASTM D 661 (% area)	10	10	10
- Chalking	No less than 8	ASTM D 4214 (% of TSA)	8	8	8
- Biological Growth	No less than 8	ASTM D 3274 (% of TSA	10	10	10
- Dirt Pick-Up	No less than 8	ASTM D 3274 (% of TSA)	8	10	10

Note 1: TSA = total surface area

FIGURE 17. Tank 2003 One Year After Application of LVBC/AZT System.

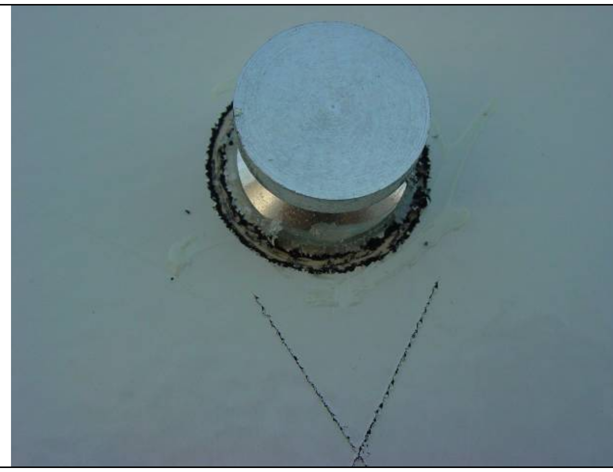

FIGURE 18. Adhesion Testing of the Coating After One Year.

5. Cost Assessment

5.1 Cost Reporting

The objective of this cost assessment is to document the expected costs of implementing an LVBC/ZVT AST maintenance painting option for use on typical AST. By comparing the expected costs of the LVBC/ZVT with typical costs of a conventional coating option, those responsible for deciding on which option is most feasible will have sound economic data to make that decision. The DESC demonstration project, consisting of the coating of Tank 5003 (10,500 SF) and the roof of Tank 5001 (2,850 SF), is considered a typical AST coating project for purposes of this economic analysis. In addition to the cost analysis, an estimate of net VOC reduction is provided by comparing VOC's released by conventional coating systems and that of the LVBC/ZVT system for a typical AST coating project. The reader is free to extrapolate any cost savings or VOC reduction for other similar projects. For example, the Navy alone performs coating maintenance on more than 15 AST/year with greater than 8,000 SF per AST.

The painting contractor cost submittal for the LVBC/ZVT demonstration project is included in Table 5-1. The use of these demonstration costs in the analysis should be tempered by the fact that initial usage of a new approach requires additional training and the development of new techniques or at least the adjustment of conventional techniques. More importantly, the painting contractor, in taking the risk of accepting a non-conventional project, typically submits a higher cost proposal to cover that risk. Thus demonstration cost proposals are typically much higher than full production costs. The estimated costs of a conventional coating system if it was applied to Tank 5003 and the roof of 5001 are also included in Table 5-1. These costs were determined via phone interview with Premier Coating Systems and represent what the proposal would have been if a conventional system had been specified for the DESC project.

For a conventional system, the existing coating would have to be completely removed and the three-coat system reapplied. The removal of the existing coating (which contains lead) by conventional blasting could create high disposal costs if TCLP testing of the blast debris shows it to be a hazardous waste (HW). Thus two costs for a conventional coating system are presented: the lower cost if the blast debris is not a HW, the higher cost if it is a HW. All costs in Table 5-1 include mobilization, labor, equipment rental, supplies, equipment maintenance, utilities, laboratory analyses, and overhead. Not considered are indirect environmental costs such as compliance audits, reporting requirements, document maintenance, and environmental management plans. These costs would not likely vary significantly between the two coating systems unless the coating removal blast debris is a HW. In that case, the greater indirect environmental costs would be included in the greater disposal cost.

Table 5 – 1. Actual Costs of the LVBC/ZVT Demonstration Project Compared with Estimated Costs for a Conventional Coating.

Description	LVBC/ZVT Contract Cost	Estimated Conventional Coating Cost
Containment	$25,760	$25,000
Coating Materials	$14,700	$20,000
Surface Preparation	$15,375	$30,000
Coating Application	$14,785	$20,000
Disposal	$25,765	$35,000 / $95,000
Total	**$97,385**	**$125,000 / $185,000**

The cost per unit area (CPUA) of the LVBC/ZVT system for the demonstration project was $7.29/SF. The estimated CPUA for a conventional coating is $9.36/SF or $13.86/SF if the coating removal debris is a HW.

5.2 Cost Analysis

5.2.1 Net Present Cost

The cost analysis method employed in this section is Net Present Cost (NPC) which is essentially Net Present Value (NPV) but considers the fact that there is no cash inflow in maintaining a coating system. In any case, the NPC formula used is

$$NPC = \sum_{t=1}^{n} [C_t \div (1+r)^t] + C_0$$

Where t = time of cost
- n = total time of project – assumed to be 32 years.
- r = discount rate – assumed to be 5%
- C_t = net cost at time t
- C_0 = capital outlay at time = 0

For conventional coating systems it is assumed that reapplication must occur every 8 years (8, 16, and 24 years after the initial application) and no spot maintenance painting occurs. The calculated NPC for conventional coating systems based on the costs presented in Table 5-1 would then be about $500,000 over 32 years ($560,000 if the removed coating debris is a HW for the initial application).

The NPC calculation for the LVBC/ZVT system is not so straight forward. The LVBC/ZVT system is a maintenance coating and can only be applied once over the existing conventional coating. Once the maintenance coating fails, the whole coating system must be removed and the conventional coating reapplied. In addition, the time to failure of the LVBC/ZVT maintenance coating has not yet been determined. Therefore, three analyses are provided.

In the first analysis, it is assumed that the maintenance coating lasts 4 years. In this case, application of the LVBC/ZVT maintenance coating is required at years 8 and 20 and the conventional coating system is applied at years 0, 12, and 24 for a total of 5 applications (3 conventional and 2 maintenance).

In the second analysis, it is assumed that the maintenance coating lasts for 6 years. In this case, the conventional coating is applied at years 0, 14, and 28 and the maintenance system is applied at years 8 and 22. Half of the remaining life of the last conventional system applied remains at year 32 for a total of 4 and a half applications (2.5 conventional and 2 maintenance).

In the third analysis, it is assumed that the maintenance coating lasts for 8 years. In this case, a conventional coating is applied at years 0, and 16 and the maintenance coating is applied at years 8 and 24 for a total of 4 applications (2 conventional and 2 maintenance). In these analyses it is assumed that the coating removal costs by abrasive blasting for the conventional coating plus maintenance coating is the same as that for the conventional coating and that the blast debris is not a HW.

With these assumptions, the NPC for the LVBC/ZVT system when it lasts 4 years is about $570,000; for 6 years it is about $507,000; and for 8 years it is about $445,000.

It can be seen that the break even point between use of the LVBC/ZVT maintenance coating approach and that of a conventional system approach is where the LVBC/ZVT system lasts for a little over 6 years. If the LVBC/ZVT maintenance coating system lasts as much as eight years then significant savings would result. **Since the longevity of the LVBC/ZVT system is a critical factor in deciding whether it is an economically feasible option, it is important to continue monitoring the performance of the demonstration project coating system for at least 8 years.**

The above analysis does not consider the case where the original coating removal debris is a HW. In that event, use of the LVBC/ZVT system would delay and not eliminate the added cost of HW disposal but the NPC would be reduced because of that delay.

The reader is free to extrapolate any cost savings for other similar projects. For example, the Navy alone performs coating maintenance on more than 15 AST per year with greater than 8,000 SF per AST.

5.2.2 Estimated net VOC Reduction.

The estimated net VOC reduction analysis follows the same logic as that of the NPC analysis; i.e., the total time considered is 32 years and the conventional system would be reapplied every 8 years on a project of equal size to that of the demonstration project. In addition, it is estimated that each application of the LVBC/ZVT system would release about 26.6 lbs of VOC while each conventional system application would release about 371 lbs (See Section 4.3.2). For a conventional system the total released over a 32 year period would simply be 4 x 371 lbs or 1484 lbs.

The estimated VOC released over 32 years with the LVBC/AZT system is dependent on how long the LVBC/AZT system lasts before recoating is required. As with the NPC analysis, three analyses are presented where the LVBC/AZT AIM Coating system lasts 4, 6, and 8 years. If the AIM Coating lasts 4 years then the total VOC released is about 1,166 lbs; for 6 years it is about 980 lbs; and for 8 years it is about 795 lbs.

From this analysis it is clear that an approach using an AIM Coating that lasts only 4 years still provides a significant reduction of VOC's compared to the continued reapplication of a conventional system. If the LVBC/ZVT AIM Coating lasts 8 years, the total VOCs released over 32 years would be reduced almost 50%.

6. Implementation Issues

6.1 Environmental Checklist

California's Occupational Safety and Health Administration (Cal/OSHA) requires the employer to submit a 24 hour prior written notification before conducting lead-related construction if the lead content is greater than or equal to 0.5 % by weight lead. The demonstration site coating systems are classified as Paint With Lead (PWL). Unless additional analytical data proves otherwise, no prior notification is required. Furthermore, all surface preparation operations have been specified for use with water which greatly reduces contractor employee exposure to all potential air borne hazards. All surface preparation liquid and paint debris waste is to be contained, collected, stored and analyzed for hazardous material concentrations prior to appropriate disposal.

The Industrial Painting Contractor was required to comply with Federal, State and Local environmental regulations throughout all aspects of the full-scale demonstration as defined in the following Sections of the demonstration plan installation contract: 1) Section 01525 "Safety and

Occupational Health Requirements," 2) Section 01572 "Construction and Demolition Waste Management," 3) Section 01575N "Temporary Environmental Controls," 4) Section 01770N "Closeout Procedures," 5) Section 02120A "Transportation and Disposal of Hazardous Materials," 6) Section 09971 "Exterior Overcoating of Aboveground Storage Tanks (AST)," and 7) Section 13283N "Removal/Control and Disposal of Paint With Lead."

6.2 Other Regulatory Issues

A regulatory representative from either the South Coast Air Quality Management District (SCAQMD) of California at Los Angeles or a southern California district representative of the Environmental Protection Agency (EPA), or both, may be contacted for participation in the project demonstration Evaluations.

6.3 End-User Issues

Concerns, reservations, and decision-making factors affecting LVBC buy-in from DOD end-users will be at a minimum since technical POC's from the Navy, Army and Air Force will review and subsequently approve all guidance documents in advance of submission to NAVFAC's Engineering Innovative Criteria Office (EICO) for guidance inclusion on the Construction Criteria Base (CCB) web site at http://www.ccb.org . The full-scale LVBC demonstration, including the NTPEP testing, will confirm acceptable LVBC performance prior to drafting new DOD AIM Coating guidance.

PolySpec L.P., the LVBC manufacturer, has sales in excess $10 mil/year and large volume production, including international sales and distribution to locations outside the continental USA, is performed daily and is not a concern.

Procurement of the LVBC will be specified in the new UFGS under Section 2, "PRODUCTS" using a combination of performance and formulation properties presented in a table or by reference to a new Master Painters Institute (MPI) Detailed Performance Standard (DPS) developed exclusively for the LVBC. Referencing either the new MPI DPS or presenting formulation and performance testing requirements within the new specification is sufficient to enable other coating manufacturer's to compete for LVBC sales and eliminates the requirement of sole source LVBC procurement. As such, LVBC procurement will then become a required contractor's material submittal when preparing a bid for work to perform AIM Coating on an AST requiring maintenance painting. Within the new UFGS under Section 3, "EXECUTION" commercial-off-the-shelf (COTS) surface preparation equipment and LVBC application equipment is commercially available and all equipment will be required to meet performance requirements set by the LVBC manufacturer as well as UFGS specification requirements.

To reiterate, demonstration results will transition into commercial guidance such as a new Master Painters Institute (MPI) Detailed Performance Standard (DPS) for the LVBC followed by developing a new Unified Facilities Guide Specification (UFGS) entitled "Maintenance Painting of Aboveground Storage Tank (AST) Exterior Surfaces." The DPS and the UFGS will be web-

displayed at http://www.paintinfo.com and http://www.ccb.org/ufgs/ufgs.htm , respectively, for direct use by Tri-service activities with AST in need of maintenance painting. In addition to the above, PolySpec L.P. will continue to produce and market the LVBC to the owner and coating contractor communities including the Bureau of Reclamation and to state Department of Transportations (DOTs). Other applications of the LVBC may include bridges, offshore structures, structural steel, antenna towers, and concrete structures.

7. References

1. Paul Anderson. 2001. *Sprayable Polysulfide Elastomer Development*, SBIR Phase I Contract #N47408-01-P-6339, October 2001.

2. Paul Anderson and Jason Bell. 2002. *Sprayable Polysulfide Elastomer Development*, SBIR Phase II Contract #N47408-01-P-6339, September 2002.

3. Jason Bell. 2002. *LPE 5020 Field Demonstration at Building 1325 Port Hueneme CA.* Power Point Presentation. August 2002.

4. Timothy D. Race, L. D. Stephenson, and Ashok Kumar. 2003. *Decision Tree for Lead-Based Paint Hazard Control and Abatement for Steel Structures.* US Army Corps of Engineers Construction Engineering research Laboratory. ERDC/CERL TR-03-3. January 2003.

5. Mike O'Donoghue, Ron Garrett, and V.J. Datta. 2002. *Overcoating Lead-Based Paint on Bridges: An Overview of Different Coating Options.* Materials Performance. September 2002.

8. Points of Contact

POINT OF CONTACT Name	ORGANIZATION Name Address	Phone/Fax/email	Role in Project
Daniel A. Zarate	Naval Facilities Engineering Service Center Code ESC 63/ Dan Zarate 1100 23rd Ave. Port Hueneme, CA 93043 - 4370	Ph. (805) 982–1057 FAX (805) 982–1074 daniel.zarate@navy.mil	NAVFAC Technical POC
Michael Zapata	HQ AFCESA/CEOA Attn: Michael G. Zapata 139 Barnes Drive, Suite 1 Tyndall AFB, FL 32403	Ph. (850) 283 - 6070FAX (850) 283 - 6219 michael.zapata@us.af.mil	Air Force Technical POC
Susan A. Drozdz	U.S. Army ERDC: Paint Technology Center Attn: CEERD CF-M Susan A. Drozdz P.O. Box 9005 Champagne, IL 61826-9005	Ph. (217) 373 – 6767 FAX (217) 373 - 6732 susan.a.drozdz@erdc.usace.army. mil	Army Technical POC

Appendix A

Unified Facilities Guide Specification
Draft

“Maintenance Coating of Steel Structures”

****
USACE / NAVFAC / AFCESA **UFGS-09 97 13.xx (DRAFT #6 9/27/06)**

Preparing Activity: NAVFAC **MasterFormat™ 2004 - 09 97 13.xx**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 1 April 2006

Revised throughout - changes not indicated by CHG tags
****

SECTION 09 97 13.xx

MAINTENANCE COATING OF STEEL STRUCTURES

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NOTE: This guide specification covers the requirements for a two coat, low VOC barrier system, polysulfide-modified-epoxy barrier coat and a UV-resistant urethane or polyurethane topcoat, for use in the industrial maintenance overcoating of previously coated, exterior structural surfaces. This system develops low internal stresses and is suitable for maintenance of poorly adhered coatings.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents**, including their organization~~designation and tele~~phone number, is on the Internet.**

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR)**.**

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.
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NOTE: This specification is for general use on steel structures in atmospheric service (non-immersion).Use on other than ground level tanks has not been tested, however, most uses in atmospheric conditions should provide satisfactory service.
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NOTE: This specification should be edited by an SSPC certified Protective Coatings Specialist (PCS)that has five or more years of experience preparing coating specifications
Design of an industrial maintenance painting project is more complex than a new design. Unlike most UFGSs for new construction, this specification is intended for maintenance only, and the final project specification must be tailored to the specifics of the project, based on the results of the Coating Condition Survey (CCS). Success on any project using this specification is highly dependent upon the accuracy and completeness of the CCS, and upon the translation of the CCS results into a complete and usable project specification.
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****
NOTE: Coating designs using this specification must be based on a competent Coating Condition Assessment(CCA), as described herein. Minimum criteria for condition of existing coating suitable for overcoating with this system is as follows:

1 **Average substrate and intercoat adhesion of more than 140 psi (ASTM-D-4541) with pull test failures primarily occurring cohesively;**
2 **Average tape test adhesion rating of no less than a rating of "3A" (ASTM-D-3359, Method A);, and**
3 **Average dry film thickness of no more than a nominal 20 mils.**

This specification is based on starting with a coating condition approximating Initial Condition "G" from SSPC Vis 4, and that the surface preparation requirements can be satisfied by SSPC SP12, WJ-4. If the results of the CCA indicate other beginning conditions or surface preparation requirements, this specification must be edited accordingly.

Severe corrosion and corrosion pitting is not addressed in this specification.

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NOTE: The metric standard for measuring coating thickness is microns (25.4 microns=1 mil – use nominal 25 microns=1 mil).
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NOTE: The products used in this specification satisfy EPA VOC regulations as of September 2005,and all anticipated VOC regulations:

-Spot Primer 300 g/l2.4 #/gal max. VOC
-Barrier coat 50 g/l 0.4#/gal max. VOC
-Polyurethane Topcoat 50 g/l 0.4#/gal max. VOC For use in areas where 300 g/l2.4 #/gal VOC exceeds VOC requirements, delete the

spot primer.

The designer shall review state and local regulations and determine whether the coating in this Section complies with restrictions on volatile organic components (VOC) and other chemical constituents. If a spot primer with lower VOC is required, any general purpose epoxy primer for steel can be substituted.
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NOTE: For purposes of this specification, the term "maintenance coating" refers to maintenance overcoating as opposed to complete removal of coatings and recoating. For maintenance coating designs, or to determine if maintenance overcoating is appropriate, a coating condition survey (CCS)should be accomplished. The CCS should be accomplished by personnel from a business that routinely performs coating evaluations, and the individual investigator should be Certified by SSPC as a Protective Coatings Specialist. The CCS should be sufficiently detailed to provide all technical information about the coatings, and structures to be coated, required to properly design the project. At a minimum, the CCS should provide a detailed report of:

1 Existing coating conditions, including condition of coating film, and the existence of potentially hazardous substances that may impact coating management (i.e. lead, cadmium, chromium);
2 Analysis of remaining coating life, suitability of overcoating, and technical requirements for overcoating;
3 Technical recommendations for the most cost effective management of existing coating systems, including any hazardous materials present in paint film; and
4 Any other information of interest to the coating system management that should be identifiable by an individual trained and experienced in the field of coating analysis, coating failure analysis, and coating design.

The scope of the CCS should be tailored to the specific project, and it should be recognized that while multiple coating failures or deficiencies may look similar to the untrained eye, the risks of generalizing to save evaluation costs are potentially very high. The cost of large-scale failure of the overcoating, and complete replacement of the coating system, is far more than the cost of a CCS for all but the smallest projects.

The risks of overcoating can usually be avoided by designing project to remove all existing coatings to bare metal, then providing appropriate surface preparation and coating application. However, the extra costs of the coating removal, especially if containing hazardous material, along with the cost of surface preparation to SSPC SP 10 Abrasive Blast to Near-White Metal, may be exorbitant compared to the costs of maintenance overcoating

where the existing coating system is in fair-to-good condition.

Additionally, NAVFAC Design Policy LetterDPL-09B-0001, Lead-containing Paint on Non-residential Structures of 26 Mar 92 provides guidance for managing paints containing lead and other hazardous materials in place. The fact that lead was highly used as a primer is indicative of its value to the corrosion control industry. Premature removal of sound lead primer is not considered to be a good management practice.

Activities should consider an annual CCS to survey all structures to be authorized for design in the coming year. When accomplished for multiple projects, the per-structure cost will decrease. By accomplishing this survey prior to design, the basis for design is fully identified.

The CCS can also be a very useful tool when used to screen structures for maintenance painting requirements. A CCS can be scoped to provide a general inspection of many structures to screen for near-term overcoating or recoating requirements, and subsequent investigation can be made to provide appropriate details for project planning and design.

It should be pointed out that the aesthetic features of a coating do not define the coating condition; they only describe how the coating looks. Many coating systems have been replaced when only the topcoat is in need of "refurbishment." Likewise, many structures such as water tanks and fuel tanks have had complete coating replacement when only the roof coating needed replacement. A CCS can identify the weak components as well as the satisfactory components, and propose solutions to make maximum use of existing resources.

SSPC: The Society for Protective Coatings (SSPC),has published a Technology Update titled SSPC TU 3Maintenance Overcoating. This document should be used as a guide for scoping the CCS, for accomplishing the CCS, and for designing the coating work.

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NOTE: Designers are encouraged to contact C. D.Gaughen, NFESC Code 63, 805 982-6776, David.gaughen@navy.mil prior to beginning a new Navy design.

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NOTE: Designers are encouraged to contact the Air Force Civil Engineering Corrosion Program Manager at HQ AFCESA/CESM, 139 Barnes Drive, Ste 1, Tyndall AFB, FL 32403, Tel 850-283-6217, prior to beginning new Air Force design.

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PART 1 GENERAL

1.1 REFERENCES

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NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide specifications.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D 3276	(2000) Painting Inspectors (Metal Substrates)
ASTM D 3925	(2002) Sampling Liquid Paints and Related Pigmented Coatings
ASTM D 4285	(1983; R 1999) Indicating Oil or Water in Compressed Air
ASTM D 7127	(2005) Measurement of Surface Roughness of Abrasive Blast Cleaned Metal Surfaces using a Portable Stylus Instrument

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 9001 (2000) Quality management systems-Requirements

MASTER PAINTERS INSTITUTE (MPI)

MPI 101 Epoxy Anti-Corrosive Metal Primer

MPI 213 Two Coat, Low VOC Barrier System for Industrial Maintenance

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Guide 12	(1998; R 2004) Guide for Illumination of Industrial Painting Projects
SSPC Guide 6	(2004) Guide for Containing Debris Generated During Paint Removal Operations
SSPC PA 1	(2000; R 2004) Shop, Field, and Maintenance Painting
SSPC PA 2	(1996; R 2004) Measurement of Dry Coating Thickness With Magnetic Gages
SSPC QP 1	(1998; R 2004) Standard Procedure for Evaluating Painting Contractors (Field Application to Complex Industrial Structures)
SSPC QP 5	(1999; R 2004) Evaluating Qualifications of Coating and Lining Inspection Companies
SSPC QS 1	(2004) Standard Procedure for Evaluating a Contractor's Advanced Quality Management System
SSPC SP 1	(1982; R 2004) Solvent Cleaning
SSPC SP 12	(2002) Surface Preparation and Cleaning of Metals by Waterjetting Prior to Recoating
SSPC SP COM	(2000; R 2004) Surface Preparation Commentary for Steel and Concrete Substrates
SSPC VIS 4	(2005) Guide and Reference Photographs for Steel Surfaces Prepared by Waterjetting

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-161	(Rev G) Identification Methods for Bulk Petroleum Products Systems Including Hydrocarbon Missile Fuels

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-595 (Rev B; Am 1) Colors, Volume 1

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910-SUBPART Z	Toxic and Hazardous Substances
29 CFR 1910.1000	Air Contaminants
29 CFR 1910.134	Respiratory Protection
29 CFR 1926.59	Hazard Communication

1.2 DEFINITIONS

Definitions are provided throughout this Section, generally in the paragraph where used, and denoted by capital letters.

1.3 SUBMITTALS

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NOTE: Submittals listed here are important to the project and to the project records. In order to improve quality, most of these submittals have been changed from gov't approval to contractor approval, thereby shifting final application responsibility to the contractor.

A “G” following a submittal item indicates that the submittal requires Government approval.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office(Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy projects.

Submittal items not designated with a "G" are considered as being for Contractor Quality Control approval.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00

SUBMITTAL PROCEDURES:

SD-05, Design Data

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NOTE: The use of containment for controlling conditions on the structure is generally cost-effective, as it allows for work in a wider range of atmospheric conditions, and generally results in a better coating project.
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Containment System

SD-06 Test Reports

Inspection Report Forms

Daily Inspection Reports

SD-07 Certificates Contract Errors, Omissions, and Other

Discrepancies Corrective Action Procedures Coating Work Plan Qualifications of Certified Industrial Hygienist (CIH) Qualifications of Certified Protective Coatings Specialist (PCS) Qualifications of Coating Inspection Company Qualifications of QC Specialist Coating Inspector Qualifications of Coating Contractors Coating Materials

SD-08 Manufacturer's Instructions

Joint Sealant Instructions

Coating System Instructions

SD-11 Closeout Submittals

Inspection Logbook; G, [_____]

1.4 QUALITY ASSURANCE

1.4.1 Contract Errors, Omissions, and Other Discrepancies

Submit all errors, omissions, and other discrepancies in contract documents the Contracting Officer within 30 days of contract award for all work covered in this Section, other than the work that will not be uncovered until a later date. All such discrepancies shall be addressed and resolved, and the Coating Work Plan modified, prior to beginning the Initial and Follow-Up phases of work. Discrepancies that become apparent only after work is uncovered shall be identified at the earliest discoverable time and submitted for resolution. Schedule time (Float)should be built into the project schedule at those points where old work is to be uncovered or where access is not available during the first 30 days after award, to allow for resolution of contract discrepancies.

1.4.2 Corrective Action (CA) CA shall be included in the

Quality Control Plan.

1.4.2.1 Corrective Action Procedures

Develop procedures for determining the root cause of each non-compliance, developing a plan to eliminate the root cause so that the non-compliance does not recur, and following up to ensure that the root cause was eliminated. Develop Corrective Action Request (CAR) forms for initiating CA, and for tracking and documenting each step.

1.4.2.2 Implement Corrective Action

The Contractor shall take action to identify and eliminate the root cause of each non-compliance so as to prevent recurrence. These procedures shall apply to non-compliance in the work, and to non-compliance in the QC System. Corrective actions shall be appropriate to the effects of the non-compliance encountered. Each CAR shall be serialized, tracked in a Log to completion and acceptance by the Contracting Officer, and retained in project records. The Corrective Action Log, showing status of each CAR, shall be submitted to the Contracting Officer monthly. A CAR may be initiated by either the Contractor or the Contracting Officer. The Contracting Officer must approve each CAR at the root cause identification stage, the plan for elimination stage, and the close out stage after verification that the root cause has been eliminated.

1.4.3 Coating Work Plan

****
NOTE: For maintenance painting, add requirement for pre-work determination of the existing surface profile. If paint removal is specified in another Section, such as a blast cleaning prior to inspection or repair, or in the lead removal Section, include this evaluation of existing profile such that the paint removal operation does not create excessive profile.
****

This work plan shall be considered as part of the Quality Control Plan.

Provide procedures for reviewing contract documents immediately after award to identify errors, omissions, and discrepancies so that any such issues can be resolved prior to project planning and development of detailed procedures.

Provide procedures for verification of key processes during Initial Phase to ensure that contract requirements can be met. Key processes shall include surface preparation, coating application and curing, inspection, and documentation, and any other process that might adversely impact orderly progression of work.

Provide procedures for all phases of coating operations, including planned work, rework, repair, inspection, and documentation. Address mobilization and setup, surface preparation, coating application, coating initial cure, tracking and correction of noncompliant work, and demobilization. Coordinate work processes with health and safety plans and confined space entry plans. For each process, provide procedures that include appropriate work instructions, material and equipment requirements, personnel qualifications, controls, and process verification procedures. Provide procedures for inspecting work to verify and document compliance with contract requirements, including inspection forms and checklists, and acceptance and rejection criteria. Provide procedures for correcting noncompliant work. Detailed procedures are required in advance to avoid delays in meeting overcoat windows as well as to avoid delays in production. Provide procedures for repairing defects in the coating film, such as runs, drips, sags, holidays, overspray, as well as how to handle correct coating thickness noncompliance, any otherareas of repair or rework that might be adversely affected

by delays inpreparing and approving new procedures.

If a procedure is based on a proposed or approved request for deviation,the deviation shall be referenced. Changes to procedures shall be noted bysubmittal number and date approved, clearly delineating old requirementsand new requirements, so that the records provide a continuous log ofrequirements and procedures.

1.4.4 Design Data

1.4.4.1 Containment System

Submit complete design drawings and calculations for the scaffolding and containment system, including an analysis of the loads which will be added to the structure by the containment system and waste materials. A registered engineer shall approve calculations and scaffold system design.

1.4.5 Qualifications

1.4.5.1 Qualifications of Certified Industrial Hygienist (CIH)

Submit name, address, telephone number, FAX number, and e-mail address of the independent third party CIH. Submit documentation that hygienist is certified by the American Board of Industrial Hygiene in comprehensive practice, including certification number and date of certification/ recertification. Provide evidence of experience with hazards involved in industrial coating application work.

1.4.5.2 Qualifications of Certified Protective Coatings Specialist (PCS)

Submit name, address, telephone number, FAX number, and e-mail address of the independent third party PCS. Submit documentation that specialist is certified by SSPC: The Society for Protective Coatings (SSPC) as a PCS, including certification number and date of certification/ recertification. If the PCS is employed by the same coating inspection company to which the coating inspector is employed, this does not violate the independent third-party requirements. The PCS shall remain certified during the entire project, and the Contracting Officer shall be notified of any change in certification status within 10 days of the change. The PCS shall not be the designated coating inspector.

1.4.5.3 Qualifications of Coating Inspection Company

Submit documentation that the coating inspection company that will be performing all coating inspection functions is certified by SSPC to the requirements of SSPC QP 5 prior to contract award, and shall remain certified while accomplishing any coating inspection functions. The coating inspection company must remain so certified for the duration of the project. If a coating inspection company's certification expires, the firm will not be allowed to perform any inspection functions, and all surface preparation and coating application work must stop, until the certification is reissued. Requests for extension of time for any delay to the completion of the project due to an inactive certification will not be considered and liquidated damages will apply. Notify the Contracting Officer of any change in coating inspection company certification status.

1.4.5.4 Qualifications of QC Specialist Coating Inspector

Submit documentation that each coating inspector is employed, and qualified to SSPC QP 5, Level III, by the selected coating inspection company. Each inspector shall remain employed by the coating inspection company while performing any coating inspection functions.

1.4.5.5 Qualifications of Coating Contractors

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NOTE: If project involves removal of paint containing hazardous materials, add requirement for SSPC QP-2 certification in section of specification where the hazardous paint removal is specified, generally UFGS 02 83 13.00 20 or 02 82 33.13 20.

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NOTE: Solicitations requiring certification for prequalification should point out the existence and location of the certification requirement on the PROJECT INFORMATION FORM. This requirement must be pointed out in the solicitation documents for the "prior to contract award" requirement to be enforceable. Certification is a special responsibility requirement pursuant to FAR 9.104-2.This is analogous to requiring bidders to have a specified level of experience or expertise and has sustained these types of special requirements.

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All Contractors and Subcontractors that perform surface

preparation or coating application shall be certified to either ISO 9001 or SSPC QP 1 and SSPC QS 1 prior to contract award, and shall remain certified while accomplishing any surface preparation or coating application. The painting Contractors and painting Subcontractors must remain so certified for the duration of the project. If a Contractor's or Subcontractor's certification expires, the firm will not be allowed to perform any work until the certification is reissued. Requests for extension of time for any delay to the completion of the project due to an inactive certification will not be considered and liquidated damages will apply. Notify the Contracting Officer of any change in Contractor certification status.

1.4.6 Protective Coating Specialist (PCS)

The PCS shall be considered a QC Specialist and shall report to the QC Manager, as specified in Section 01 45 00.00 20 CONSTRUCTION QUALITYCONTROL. The PCS shall approve all submittals prior to submission to the QC Manager for approval or submission to the government for approval.

1.4.7 Pre-Application Meeting

After approval of submittals but prior to the initiation of coating work,
Contractor representatives, including at a minimum, project superintendent and QC manager, paint foreman, coating inspector, and PCS shall have a pre-application coating preparatory meeting. This meeting shall be in addition to the pre-construction conference. Specific items addressed shall include: corrective action requirements and procedures, coating work plan, safety plan, coordination with other Sections, inspection standards, inspection requirements and tools, test procedures, environmental control system, safety plan, and test logs. Notify Contracting Officer at least ten days prior to meeting.

1.5 PRODUCT DATA

1.5.1 Joint Sealant Instructions

Submit manufacturer's printed instructions including detailed application procedures, minimum and maximum application temperatures, and curing procedures. Include materials safety data sheets (MSDS) for materials to be used at the job site

in accordance with 29 CFR 1926.59.

1.5.2 Coating System Instructions

Submit manufacturer's printed instructions including detailed mixing and application procedures, number and types of coats required, minimum and maximum application temperatures, and curing procedures. Include materials safety data sheets (MSDS) for materials to be used at the job site in accordance with 29 CFR 1926.59.

1.6 DELIVERY AND STORAGE

Ship, store, and handle materials in accordance with SSPC PA 1, and as modified in this Section. Maintain temperature in storage spaces between 5and 29 degrees C 40 and 85 degrees F, and air temperature more than 3degrees C 5 degrees F above the dew-point at all times. Inspect materials for damage prior to use and return non-compliant materials to manufacturer. Remove materials with expired shelf life from government property immediately and notify the Contracting Officer.

If materials are approaching shelf life expiration and an extension is desired, samples may be sent to the manufacturer, along with complete records of storage conditions, with a request for shelf life extension. If the manufacturer finds the samples and storage data suitable for shelf life extension, the manufacturer may issue an extension, referencing the product evaluation and the review of storage records. Products may not be extended longer than allowed in the product specification.

1.7 COATING HAZARDS

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NOTE: This specification Section should be used with UFGS 01 35 29 "SAFETY REQUIREMENTS".

****

Ensure that employees are trained in all aspects of the safety plan. Specified coatings may have potential health hazards if ingested or improperly handled. The coating manufacturer's written safety precautions shall be followed throughout mixing, application, and curing of the coatings. During all cleaning, cleanup, surface preparation, and paint application phases, ensure that employees are protected from toxic and

hazardous chemical agents which exceed concentrations in 29 CFR 1910.1000.
Comply with respiratory protection requirements in 29 CFR 1910.134. The
CIH shall approve work procedures and personal protective equipment.

1.8 JOB SITE REFERENCES

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NOTE: Include any other jobsite related references that might be added during design.
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Make available to the Contracting Officer at least one copy each of ASTM D3276, ASTM D 3925, ASTM D 4285, ASTM D 7127, SSPC SP COM, SSPC SP 1, SSPCPA 1, SSPC PA 2, SSPC Guide 6, SSPC VIS 4, SSPC SP 12, SSPC QP 1, SSPC QS 1,and an SSPC Certified Contractor Evaluation Form at the job site.

PART 2 PRODUCTS

2.1 JOINT SEALANT

Polysulfide joint sealant as recommended by the polysulfide barrier coat
manufacturer.

2.2 COATING MATERIALS

2.2.1 Spot Primer

MPI 101, VOC

Range E3

2.2.2 Barrier Coating System (Intermediate Coat

and Topcoat) MPI 213

[2.3 COLOR IDENTIFICATION OF FUEL HANDLING AND STORAGE

FACILITIES

Piping, conduit, and tank identification shall be in accordance withMIL-STD-161. Mark direction of fluids in accordance with MIL-STD-161. The NATO symbol for JP-8 is F-34.

]2.4 COATING SAMPLE COLLECTION KIT

Provide a kit that contains one liter quart can for the base of each coating material, an appropriately sized can for each activator, dipping cups for each component to be sampled. Mark cans for the appropriate component. Retain for duration of project.

2.5 TEST KITS

2.5.1 Test Kit for Measuring Chloride, Sulfate and Nitrate Ions on Steel and Coated Surfaces

Provide test kits called CHLOR*TEST CSN Salts, as manufactured by CHLOR*RID International Inc. of Chandler, Arizona (www.chlor-rid.com) or equal. An "equal" test kit shall meet the following requirements:

a. Kit contains all materials, supplies, tools and instructions for field testing and on-site quantitative evaluation of chloride, sulfate and nitrate ions;
b. Kit extract solution is acidic, factory pre-measured, pre-packaged, and of uniform concentration;

c. Kit components and solutions are mercury free and environmentally friendly;

d. Kit contains new materials and solutions for each test extraction;

e. Extraction test container (vessel, sleeve, cell. etc.) creates a sealed, encapsulated environment during salt ion extraction;
f. Test extract container is suitable for testing the following steel surfaces: horizontal (up/down configuration), vertical, flat, curved, smooth, pitted, and rough;
g. All salt ion concentrations are directly measured in micrograms per square centimeter.

2.5.2 Test Kit for Identifying Amine Blush on Epoxy Surfaces

After coating and/or primer has hardened and prior to applying the next coat, test for unreacted amines using the AMINE BLUSH CHECK, manufactured by Elcometer, Rochester Hills, Michigan, or equal. To be considered for approval as an "equal" test kit it shall meet the following requirements:

a. Be a completely self-contained field test kit with all materials, supplies, tools and instructions to perform tests and indicate the presence of unreacted amines;
b. Use an identifiable, consistent, uniform, pre-packaged, factory pre-measured indicating solution;
c. Kit contains no mercury or lead and is environmentally friendly;
d. Kit contains a solution of an unreacted amine for the purpose of "self checking" the indicator solution;

2.6 White Aluminum Oxide Non-skid Grit

Size #60, dust free (washed and dry), minimum 99 percent pure, having the following sieve analysis when tested in accordance with ASTM E 11 using a1000 gram 2.2 pound sample:

Sieve #	% Retained
40	0
50	15-40
60	60-85

PART 3 EXECUTION

Perform all work, rework, and repair in accordance with approved procedures in the Coating Work Plan.

3.1 REMOVAL OF COATINGS CONTAINING HAZARDOUS MATERIALS

****

NOTE: Include UFGS 02 82 33.13 20 in any project specification that requires removal or disturbance of coating containing hazardous materials. Include a contractor qualification requirement similar to the article entitled "Qualifications of Coating Contractors" in Part 1 of this Section, except that the contractor shall be qualified to SSPC QP-2,Category A. The removal of coatings containing hazardous materials and application of new coating system can be accomplished in a continuous operation if the contractor provides appropriate coordination of removal, cleaning, and coating application. It is specified as two separate operations to allow separate contractors to accomplish different phases of project. With the

use of SSPC QP-1 and QP-2requirements in contracts, the same contractor will generally be accomplishing both phases of work, and will probably want to perform both phases as a single operation so as not to have to prepare surface twice. To accomplish the coating removal and recoating in a continuous operation, the contractors plan must be scrutinized for appropriate controls on the removal process, and on the surface preparation/coating application process. Delete this paragraph if no paint containing hazardous material is to be removed.

****

Coatings containing hazardous materials and identified for disturbance during surface preparation, including removal, shall be handled in accordance with Section 02 82 33.13 20 REMOVAL AND DISPOSAL OF LEAD CONTAINING PAINT. Coordinate surface preparation requirements from Section02 82 33.13 20 REMOVAL AND DISPOSAL OF LEAD CONTAINING PAINT with this Section.

]3.2 COATING SAMPLE COLLECTION

Sample and test materials delivered to the jobsite. Notify Contracting Officer three days in advance of sampling. The QC Manager and either the PCS or coating inspector shall witness all sampling.

Provide a sample collection kit as required in paragraph COATING SAMPLE COLLECTION KIT. From each lot, obtain a one liter quart sample of each base material, and proportional samples of each activator based on mix ratio, by random selection from sealed containers in accordance with ASTM D3925. Prior to sampling, mix contents of each sealed container to ensure uniformity. For purposes of quality conformance inspection, a lot is defined as that quantity of materials from a single, uniform batch produced and offered for delivery at one time. A batch is defined as that quantity of material processed by the manufacturer at one time and identified by number on the label. Identify samples by designated name, specification number, batch number, project contract number, sample date, intended use, and quantity involved.

3.3 SURFACES TO BE COATED

Coat exterior surfaces of [tank] [structure] [__________]

[including steel roof, shell, legs, stair, railing, and other exterior appurtenances].

3.4 LIGHTING

Provide lighting for all work areas as prescribed in SSPC Guide 12.

3.5 ENVIRONMENTAL CONDITIONS

3.5.1 Containment

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NOTE: Experience has shown that containment provides cost-effective control of environmental conditions, and the better conditions result in a better coating product.

SSPC Guide 6, has four classes of containment, from Class 1 being the highest level of control. Generally Classes 1 and 2 are only required for removal of hazardous materials, while Class 3 is probably satisfactory for most coating operations. Class 4 requires minimal "knockdown" of airborne debris, and is not generally usable as an airborne particulate control measure.

****

Design and provide a containment system for the capture, containment, collection, storage and disposal of the waste materials generated by the work under this Section, to meet the requirements of SSPC Guide 6, Class[1][2][3]. Vapor concentrations shall be kept at or below 10 percent of Lower Explosive Limit (LEL) at all times. Containment may be designed as fixed containment for complete structure or portable containment for sections of structure, however, containment shall remain in any one place from beginning of abrasive blasting through initial cure of coating. Waste materials covered by this paragraph shall not include any material or residue from removal of coatings containing lead, chromium, cadmium, PCB, or any other hazardous material.

It is the Contractors responsibility to insure the feasibility and workability of the containment system. The Contractor shall perform his operations and work schedule in a manner as to minimize leakage of the containment system. The containment system shall be properly maintained and shall not deviate from the approved drawings. If the containment system fails to function satisfactorily, the Contractor shall suspend all operations, except those required to minimize adverse impact on the environment or government property.

Operations shall not resume until modifications have been made to correct the cause of the failure.

3.5.2 Automated Monitoring Requirements

Provide continuous monitoring of temperature, relative humidity, and dewpoint data at pertinent points on the structure, during surface preparation, coating application, and initial cure. Locate sensors to provide pertinent data for the surface preparation and coat application being performed. Monitor any heating, cooling, or dehumidification equipment used. Make data available to the Contracting Officer through Internet access. Provide monitoring equipment to perform as follows:

a. Data is collected in the field unit in one minute increments, and available for download (on-site) in a standard format. Contractor shall collect this data and make available to the Contracting Officer;

b. Monitoring equipment shall have backup power such that data collection and transmission to web server will be uninterrupted during the entire period of the dehumidification requirement;
c. Monitoring equipment shall have capability to measure surface temperatures at a minimum of four locations anywhere on a 150 foot diameter by 50 foot high tank;
d. Monitoring equipment shall have capability to measure interior and exterior dry bulb temperature (DB), relative humidity (RH), and dewpoint temperature (DP);
e. Data shall be available continuously through secure Internet connection, using widely available web browsers;
f. Internet accessible data shall be collected and stored in maximum 15 minute increments, and lag time between data collection and online availability shall be no greater than 70 minutes;
g. Internet accessible data shall be available for viewing online in tabular format, and graphical format using selected data;
h. Internet accessible data shall be available for download in user-defined segments, or entire project to date, in a standard format usable by Microsoft Excel and other spreadsheet programs.
Internet-based controls shall provide alerts to pre-designated parties through email messaging;

j. Internet-based controls shall monitor data uploads from field unit and issue alert if data not initiated within 60 minutes of last upload;
k. Internet-based controls shall monitor operation of DH equipment and issues alert when power remains off for more than 15 seconds, or if pre-determined temperature, RH, or DP conditions are exceeded;

The requirements listed here were developed around the Munters Exactaire Monitoring System, as this was the only monitoring system having Internet connectivity known to be commercially available. There is no requirement for connectivity of the monitoring system to control the DH equipment, therefore, any combination of equipment having the required functionality will be accepted.

3.6 SURFACE PREPARATION

3.6.1 Surface Standard

Preparing a surface standard for maintenance coating is no less important than a surface standard for new coating, although, there will likely be a variety of conditions existing for the maintenance painting work. It is important to choose representative areas of all conditions, and expeciallly those that will require special procedures. The development of surface standards for each differing condition is one way of verifying procedures, and should be used to determine the limits of the procedures, as well as the suitability of the controls established for the project.

3.6.2 Water Cleanliness

Use water of appropriate cleanliness to achieve final surface condition requirements for all washing and surface preparation. The controlling requirement is the final surface cleanliness conditions, and the water must be potable water, modified as required to meet final surface requirements. Due to variation in potable water production from source to source and from day to day for any one source, water may require filtration, ion exchange, or other suitable techniques to achieve the level of cleanliness required.

3.6.3 Pre-Preparation Testing for Surface Contamination

Perform testing, abrasive blasting, and testing in the

prescribed order.

3.6.3.1 Pre-Preparation Testing for Oil and Grease Contamination

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NOTE: When specifying maintenance painting, use a water based pH neutral degreaser to avoid damaging existing coating.
****

Inspect all surfaces for oil and/or grease contamination using two or more of the following inspection techniques: 1) Visual inspection, 2) WATERBREAK TEST, 3) CLOTH RUB TEST. Note that oil and/or grease contamination does not have to be removed at this stage as long as the water based surface preparation has been verified to remove all oil and grease contamination. Alternatively, clean using a water based pH neutral degreaser in accordance with SSPC SP 1, and recheck for contamination until surfaces are free of oil and grease.

WATER BREAK TEST - Spray atomized mist of distilled water onto surface, and observe for water beading. If water "wets" surface rather than beading up, surface can be considered free of oil or grease contamination. Beading of water (water forms droplets) is evidence of oil or grease contamination.

CLOTH RUB TEST - Rub a clean, white, lint free, cotton cloth onto surface and observe for discoloration. To confirm oil or grease contamination in lightly stained areas, a non-staining solvent may be used to aid in oil or grease extraction. Any visible discoloration is evidence of oil or grease contamination.

3.6.3.2 Pre-Preparation Testing for Soluble Salts Contamination

Test surfaces for soluble salts. Soluble salt testing is also required in paragraph PRE-APPLICATION TESTING FOR SOLUBLE SALTS CONTAMINATION as a final acceptance test of prepared surfaces after surface preparation, and successful completion of this phase does not negate that requirement. This phase is recommended since pre-preparation testing and washing are generally more advantageous than attempting to remove soluble salt contamination just prior to coating application. Areas of coatingde gradation are likely to be areas of soluble salt contmination. Effective removal of soluble salts will require removal of any barrier to the steel surface, including rust. This procedure may necessitate combinations of water rinsing

and cleaning using a solution of water washing and soluble salts remover. The soluble salts remover shall be acidic, biodegradable, nontoxic, noncorrosive, and after application, will not interfere with primer adhesion. Delays between testing and preparation, or testing and
coating application, may allow for the formation of new contamination.
Test methods and equipment used in this phase are selected at the
Contractor's discretion.

3.6.4 Water Cleaning

****

NOTE: Surface preparation must be designed to match the project. Surface preparation to SSPC SP 12,WJ-4, light flash rusting, generally produces the ideal conditions for application of the specified coating system to an existing coating. On occasion, surface preparation using more or less aggressive surface preparation methods may be required and this specification should be edited accordingly.

****

General surfaces to SSPC SP 12, WJ-4. Areas of general or spot corrosion to SSPC SP 12, WJ-2/L, bare metal. All prepared surfaces shall conform to the descriptions in SSPC SP 12 and the appropriate reference photographs in SSPC VIS 4 at the time of coating application.

3.6.5 Pre-Application Testing For Surface Contamination

3.6.5.1 Pre-Application Testing for Oil and Grease Contamination

Ensure surfaces are free of contamination as described in paragraph PRE-PREPARATION TESTING FOR OIL AND GREASE CONTAMINATION, except that only questionable areas need be checked for beading of water misted onto surface.

3.6.5.2 Pre-Application Testing for Soluble Salts Contamination

Test surfaces for chloride contamination using the Test Kit described in TEST KIT FOR MEASURING CHLORIDE, SULFATE AND NITRATE IONS ON STEEL AND COATED SURFACES. Test all surfaces at rate of three tests for the first 100 square meters 1000 square feet plus one test for each additional 200 square meters 2000 square feet or part thereof. Concentrate testing

of bare steel at areas of coating failure to bare steel and areas of corrosion pitting. One or more readings greater than 3 micrograms per square centimeter of chlorides or 10 micrograms per square centimeter of sulfates or 5micrograms per square centimeter of nitrates is evidence of soluble salt contamination. Reject contaminated surfaces, wash as discussed in paragraph PRE-PREPARATION TESTING FOR SOLUBLE SALTS CONTAMINATION, allow to dry, and re-test until all required tests show allowable results. Label all test tubes and retain for test verification.

3.6.5.3 Pre-Application Testing for Surface Cleanliness

Apply coatings to clean surfaces. To test surfaces, apply strip of clear adhesive tape to surface and rub onto surface with finger. When removed, the tape should show little or no dust, chalk, or other contaminant. Reject contaminated surfaces and retest. Test surfaces at rate of three tests for the first 100 square meters 1000 square feet plus one test foreach additional 100 square meters 1000 square feet or part thereof.Provide two additional tests for each failed test or questionable test. Attach test tapes to Daily Inspection Reports.

3.7 MIXING AND APPLICATION OF SEALANT AND COATING SYSTEM

3.7.1 Preparation of Sealant and Coating Materials for Application

Each of the sealant, primer, intermediate, and topcoat materials is a
two-component material supplied in separate containers.

3.7.1.1 Mixing Sealant and Coating Materials

Mix in accordance with manufacturer's instructions, which may differ for each product. Do not mix partial kits except when using plural component equipment. Do not alter mix ratios. Mix materials in same temperature and humidity conditions specified in paragraph DELIVERY AND STORAGE. Allow mixed material to stand for the required induction time based on its temperature.

3.7.1.2 Mixing Topcoat Material

Do not mix partial kits, or alter mix ratios. Use a mixer that

does not create a vortex. Do not add solvent without specific written recommendation from the manufacturer. No induction time is required, only thorough agitation of the mixed material.

3.7.1.3 Pot Life

Apply mixed products within stated pot life for each product. Stop applying when material becomes difficult to apply in a smooth, uniform wet film. Add all required solvent at time of mixing. Do not add solvent to extend pot life. Pot life is based on standard conditions at 21 degrees C70 degrees F and 50 percent relative humidity. For every 10 degrees C 18degrees F rise in temperature, pot life is reduced by approximately half, and for every 10 degrees C 18 degrees F drop it is approximately doubled. Usable pot life depends on the temperature of the material at the time of mixing and the sustained temperature at the time of application. Other factors such as the shape of the container and volume of mixed material may also affect pot life.

3.7.1.4 Application Conditions and Recoat Windows

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NOTE: These new requirements are provided in an attempt to prevent the significant number of intercoat delamination failures that are frequently found on industrial structures. The very strict requirements on application conditions and recoat windows may require work during abnormal hours, including weekends. Contractor work hours should allow for such during coating application.

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NOTE: Cold-weather application is not covered by this specification. If a project is designed for coating in cold weather, then the enclosure and heating requirements may be significant. It is not intended that contractors be forced to apply coatings in cold weather, however, the underlying premise is that coatings must be applied within the specified temperature ranges. A cold-weather specification should not be used to simply save money, as the coating system will generally not have the same longevity as one applied within 60-100degrees F.

****

The application condition requirements for the coating system are very time and temperature sensitive, and are intended to avoid the delamination problems frequently found on industrial structures. Plan coating application to ensure that specified

temperature, humidity, and condensation conditions are met. If conditions do not allow for orderly application of sealant, primer, stripe coat, intermediate coat and topcoat, use appropriate means of controlling air and surface temperatures, as required. Partial or total enclosures, insulation, heating or cooling, or other appropriate measures may be required to control conditions to allow for orderly application of all required coats.

Maintain air and steel surface temperature between 16 and 38 degrees C 60and 100 degrees F during application and the first four hours of cure for epoxy coats and the first eight hours of cure for polyurethane coats. Maintain steel surface temperature more than 3 degrees C 5 degrees F above the dew-point of the ambient air for the same period.

Use Table entitled "RECOAT WINDOWS" to determine appropriate recoat windows for each coat after the initial coat. Apply each coat during appropriate RECOAT WINDOW of preceding coat. Missing more than one RECOAT WINDOW may require complete removal of coating if maximum total coating thickness requirements cannot be achieved.

If coating is not applied during RECOAT WINDOW, or if surface temperature exceeds 49 degrees C 120 degrees F between applications, provide GLOSSREMOVAL, apply next coat within 24 hours.

RECOAT WINDOWS

POLYSULFIDE OVER EPOXY

Temperature degrees F	60-70	71-80	81-90	91-100	101-110	111-120
Temperature degrees C	16-21	22-27	28-32	33-38	39-43	44-49
RECOAT WINDOW(Hrs.)	24-72	18-60	16-48	12-36	8-18	4-6

POLYSULFIDE OVER POLYSULFIDE

Temperature degrees F	60-70	71-80	81-90	91-100	101-110	111-120
Temperature degrees C	16-21	22-27	28-32	33-38	39-43	44-49
RECOAT WINDOW(Hrs.)	24-72	18-60	16-48	12-36	8-18	4-6

POLYURETHANE OVER POLYSULFIDE

Temperature degrees F	60-70	71-80	81-90	91-100	101-110	111-120
Temperature degrees C	16-21	22-27	28-32	33-38	39-43	44-49

RECOAT WINDOW(Hrs.)	24-96	24-72	16-48	12-36	10-24	8-16

POLYURETHANE OVER POLYURETHANE

Temperature degrees F	60-70	71-80	81-90	91-100	101-110	111-120
Temperature degrees C	16-21	22-27	28-32	33-38	39-43	44-49
RECOAT WINDOW(Hrs.)	8-48	6-48	4-36	3-24	2-12	1-2

The temperature ranges shown in the table above are for determining recoat windows. Choose recoat window based on the highest surface temperature that was sustained for one or more hours between coats. This applies to the entire time between coats. Measure and record air and surface temperatures on hourly basis to determine appropriate recoat windows. If surface temperature goes above 38 degrees C 100 degrees F, measure and record temperatures every half hour.

GLOSS REMOVAL (epoxy primer) - Where required, hand sand in a linear fashion to remove gloss using 120-200 grit wet/dry sandpaper, followed by solvent wiping with a clean rag soaked with denatured alcohol to remove all dust. GLOSS REMOVAL of primer coat is to scarify surface and shall consist of removal of approximately 25 microns 1 mil of coating. If steel is exposed during GLOSS REMOVAL, repair in accordance with paragraph PROCEDUREFOR HOLIDAY AND SPOT REPAIRS OF NEWLY APPLIED COATING.

GLOSS REMOVAL (polysulfide) - Where required, hand scrub to clean surface and remove gloss using scotch brite pads and running water. Follow scrubbing with a full pressure washing using a minimum of 3000 psi at the nozzle.

3.7.2 Amine Blush Testing of Epoxy Coat Prior to Overcoating

Test epoxy surfaces prior to application of joint sealant, epoxy coat, or polyurethane topcoat for amine blush contamination using the Test Kit described in paragraph TEST KIT FOR IDENTIFYING AMINE BLUSH ON EPOXYSURFACES. Test all surfaces at rate of three tests for the first 100 square meters 1000 square feet plus one test for each additional 200 square meters2000 square feet or part thereof. If one or more tests show positive results for amine blush contamination, either treat all surfaces using the approved amine blush removal procedure or increase testing to ensure that all contamination is located, and then treat identified contamination using the

approved procedure.

3.7.3 Application of Coating System and Joint Sealant

Apply coatings in accordance with SSPC PA 1 and as specified herein. Apply coatings to surfaces that meet all stated surface preparation requirements.

After application of primer coat and prior to application of each subsequent coat, perform testing prescribed in paragraph PRE-APPLICATIONTESTING FOR SURFACE CONTAMINATION, as necessary, to ensure minimal intercoat contamination. This testing may be reduced to one half of the prescribed rate for bare steel if the testing indicates no contamination when sampling is evenly distributed over surfaces being tested. If contamination is found between coats, revert to the specified testing rate. Generally, oil and grease contamination and soluble salts contamination are not encountered if subsequent coats are applied within specified recoat windows and unusual atmospheric events do not occur. Such atmospheric events as a coastal storm blowing onshore can bring unusual chloride contamination. Concern for intercoat contamination should be continually prevalent, and spot testing should be accomplished to verify satisfactory conditions. Where visual examination or spot testing indicates contamination, perform sufficient testing to verify non-contamination, or to define extent of contamination for appropriate treatment.

Apply each coat in a consistent wet film, at 90 degrees to previous coat. Ensure that primer and intermediate coat "cold joints" are no less than 150mm six inches from welds. Apply stripe coat by brush. For convenience, stripe coat material may be delivered by spray if followed immediately with brush-out and approved procedures include appropriate controls on thickness. Apply all other coats by spray application. Use appropriate controls to prevent airborne coating fog from drifting beyond[[15][____]feet [three][____] meters from the structure perimeter] [the tank berm]. Cover or protect all surfaces that will not be coated. The cleanliness, temperature, recoat windows, and airborne paint containment requirements may necessitate the use of enclosures, portable shelters, or other appropriate controls.

Apply coatings at the following specified thickness:

Coat	Minimum DFT (Mils)	Maximum DFT (Mils)
Spot Primer	4	6
Intermediate coat	10	15
Top	2	3

Coat	Minimum DFT (Microns)	Maximum DFT (Microns)
Primer	100	150
Intermediate coat	450	550
Top	50	75

3.7.3.1 Application of Primer

Apply primer coat to all areas prepared to bare metal.

3.7.3.2 Application of Joint Sealant

Apply joint sealant within recoat window of primer. Apply sealant to back-to-back steel joints that are less that 3/8 inches wide and are not seal welded. Apply sealant to top and bottom, or each side, of narrow joints.

3.7.3.3 Application of Intermediate Coat

Apply intermediate coat within RECOAT WINDOW of primer coat.

3.7.3.4 Non-skid for Stairs and Top Where non-skid is required, apply a second intermediate coat of 10 to 15mils, and immediately follow with application of non-skid grit, broadcast at the rate of 2 pounds per 100 square feet, and back roll. Apply topcoat as specified.

3.7.3.5 Application of Topcoat

Make all required repairs to primer and intermediate coats as specified in paragraph entitled "Procedure for Holiday and Spot Repairs of Newly Applied Coating" prior to applying topcoat. Apply topcoat within RECOAT WINDOW of intermediate coat. The polyurethane topcoat may require multiple passes to achieve desired aesthetics and required thickness. Touch-up blemishes and defects within recoat window of polyurethane topcoat. Retain sample of polyurethane topcoat, from the same batch used to coat structure, to make touch-ups that might be required

later. Leave two each quart kits of topcoat material for future touch-ups.

3.7.3.6 Procedure for Holiday and Spot Repairs of Newly Applied Coating

Repair coating film defects at the earliest practicable time, preferably before application of the succeeding coat. Observe all requirements for soluble salts contamination, cleanliness between coats, and application conditions. Prepare defective area in accordance with SSPC SP 12, WJ 2/Land feather coating as required to leave 100 mm 4 inches of each succeeding coat feathered and abraded. Protect adjacent areas from damage and overspray. Remove residue and solvent wipe the prepared area plus an additional 100 mm 4 inches beyond the prepared area with clean denatured alcohol. Apply each coat within RECOAT WINDOW of preceeding coat. Within four hours of preparation, apply primer to prepared steel and feather onto prepared coating. Apply intermediate coat to primed area and feather to prepared intermediate area. Apply topcoat to intermediate coat and feather to prepared topcoat. Apply each repair coat to approximate thickness of surrounding coating system.

3.7.3.7 Structure Occupancy After Coating Application

Use clean canvas or other approved shoe covers when walking on coated surfaces, regardless of curing time allowed. For heavily trafficked areas, provide cushioned mats for additional protection.

3.8 PROJECT IDENTIFICATION

At the completion of the work, stencil the following information on the [structure][tank exterior adjacent to the main man way opening] in 3/4 to one inch Helvetica style letters of contrasting color using acrylic stencil paint:

Date exterior coated:
Project Number:
Contractor:
Address:
Existing Coating Thickness: ____________

Overcoat System
Surface Prep: _________

Primer: ____________ Thickness: ____
Intermediate:____________ Thickness: ____
Topcoat: ____________ Thickness: ____
Total Thickness: ____

3.9 FIELD QUALITY CONTROL

For marking of tank surfaces, use chalk for marking bare steel, and water based markers for marking coated surfaces, and remove marks prior to coating. Do not use any wax or grease based markers, or any other markers that leave a residue or stain.

3.9.1 Coating Inspector

The coating inspector shall be considered a QC Specialist and shall report to the QC Manager, as specified in Section 01 45 00.00 20 CONSTRUCTIONQUALITY CONTROL. The Coating Inspector shall be present during all pre-preparation testing, surface preparation, coating application, initial cure of the coating system, during all coating repair work, and during completion activities as specified in Section 01 45 00.00 20 CONSTRUCTIONQUALITY CONTROL. The Coating Inspector shall provide complete documentation of conditions and occurrences on the job site, and be aware of conditions and occurrences that are potentially detrimental to the coating system. The requirements for inspection listed in this Section are in addition to the QC inspection and reporting requirements specified in Section 01 45 00.00 20 CONSTRUCTION QUALITY CONTROL.

3.9.2 Field Inspection

3.9.2.1 Inspection Requirements

Perform field inspection in accordance with ASTM D 3276 and the approved Coating Work Plan. Document Contractor's compliance with the approved Coating Work Plan.

Provide all tools and instruments required to perform the required testing, as well as any tools or instruments that the inspector considers necessary to perform the required inspections and tests. Document each inspection and test, including required hold points and other required inspections

and tests, as well as those inspections and tests deemed prudent from on-site evaluation to document a particular process or condition, as follows:

a. Location or area;
b. Purpose (required or special);
c. Method;
d. Criteria for evaluation;
e. Results;
f. Determination of compliance;
g. List of required rework;
h. Observations.

Collect and record Environmental Conditions as described in ASTM D 3276 on a 24 hour basis, as follows:

a. During surface preparation, every two hours or when changes occur;
b. During coating application and the first four days of initial cure, every hour, or when changes occur;
c. Note location, time, and temperature of the highest and lowest surface temperatures each day;
d. Use a non-contact thermometer to locate temperature extremes, then verify with contact thermometers.

Document all equipment used in inspections and testing, including manufacturer, model number, serial number, last calibration date and future calibration date, and results of on-site calibration performed.

Document Contractors compliance with the approved Coating Work Plan.

3.9.2.2 Inspection Report Forms

Develop project-specific report forms as required to report measurements, test results, and observations being complete and conforming to contract requirements. This includes all direct requirements of the contract documents and indirect requirements of referenced documents. Show acceptance criteria with each requirement and indication of conformity of each inspected item. The data may be in any format, but must be legible and presented so that entered data can be quickly compared to the appropriate requirement.

3.9.2.2 Daily Inspection Reports

Submit one copy of daily inspection report completed each day when performing work under this Section, to the Contracting Officer. Note all non-compliance issues, and all issues that were reported for rework in accordance with QC procedures of Section 01 45 00.00 20 CONSTRUCTION QUALITY CONTROL. Each report shall be signed by the coating inspector and the QC Manager. Submit report within 24 hours of date recorded on the report.

3.9.2.3 Inspection Logbook

A continuous record of all activity related to this Section shall be maintained in an Inspection Logbook on a daily basis. The logbook shall be hard or spiral bound with consecutively numbered pages, and shall be used to record all information provided in the Daily Inspection Reports, as well as other pertinent observations and information. The Coating Inspector's Logbook that is sold by NACE is satisfactory. Submit the original Inspection Logbook to the Contracting Officer upon completion of the project and prior to final payment.

3.9.2.4 Inspection Equipment

All equipment shall be in good condition, operational within its design range, and calibrated as required by the specified standard for use of each device.

3.10 FINAL CLEANUP

Following completion of the work, remove debris, equipment, and materials from the site. Remove temporary connections to Government or Contractor furnished water and electrical services. Restore existing facilities in and around the work areas to their original condition.

-- End of Section -

Appendix B

"Data Quality Assurance/Quality Control Plan"

Appendix B

"Data Quality Assurance/Quality Control Plan"

D.1 Quality Assurance for Laboratory Testing
PolySpec L.P.'s sponsored laboratory testing of the LVBC under the American Association of State Highway & Transportation Officials (AASTO) National Transportation Production Evaluation Program (NTPEP) will be performed by one of two certified AASTO-Select Test Facilities, Corrosion Control Consultants and Labs, Inc. of Grand Rapids, MI.

D.2 Quality Assurance for LVBC/ZVT Coating Contractor
Only the Society for Protective Coatings (SSPC) QP-1 "Standard Procedure for Evaluating Painting Contractors (Field Application to Complex Industrial Structures)" certified coating contractors will be permitted to submit a demonstration bid for this full-scale demonstration. Currently three coating contractors hold QP-1 certifications within the state of California.

D.3 Quality Assurance for Field Tests and Inspection
ADD NEW GUIDE SPEC HERE CONTENTS UFGS 09 97 13.27 "EXTERIOR COATING OF STEEL STRUCTURES," Section 3.8 "FIELD TESTS AND INSPECTION," subparts 3.8.1, 3.8.2, 3.8.2.1, 3.8.2.2, 3.8.2.3, and 3.8.2.4, entitled Coating Inspector, Field Inspector, Inspection Requirements, Daily Inspection Reports, Inspection Logbook, and Inspection Equipment, respectively, will be incorporated into the full-scale field demonstration contract.

D.4 Quality Control Plan
Under the heading below of "Quality Control Plan," the first five pages of UFGS – 01450N "Construction Quality Control" are presented and will be slightly modified for use as a part of the full-scale field demonstration Quality Control Plan.

“Quality Control Plan”

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**************************************************************************
USACE / NAVFAC / AFCESA                   UFGS-01450N (April 2003)
                                          -------------------------------
Preparing Activity:  <PRA>NAVFAC</PRA>                Superseding
                                          UFGS-01450N (Febuary 2001)

                  UNIFIED FACILITIES GUIDE SPECIFICATIONS

          Revised throughout - changes not indicated by CHG tags
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SECTION TABLE OF CONTENTS

DIVISION 01 - GENERAL REQUIREMENTS

01450N

[DESIGN AND]CONSTRUCTION QUALITY CONTROL

04/03

-- End of Section Table of Contents --

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USACE / NAVFAC / AFCESA                   UFGS-01450N (April 2003)
                                          -------------------------------
Preparing Activity:  <PRA>NAVFAC</PRA>              Superseding
                                          UFGS-01450N (Febuary 2001)

                  UNIFIED FACILITIES GUIDE SPECIFICATIONS

          Revised throughout - changes not indicated by CHG tags
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01450N

[DESIGN AND]CONSTRUCTION QUALITY CONTROL
04/03

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NOTE: This guide specification covers the preparation and use of Design-Build Quality Control and Design-Bid-Build Quality Control and as such must be edited for the acquisition method used. This guide specification covers the requirement for Quality Control (QC) for projects $100,000 and greater. It may be also used for smaller, complex projects at the discretion of the Government. This section requires specific editing of the QC requirements. Consult the EFD/EFA/OICC Construction Quality Management (CQM) Staff on appropriate guide specification to use. This section, as edited, shall be reviewed and approved by the CQM Staff prior to the 100 percent design submission.

This guide specification includes tailoring options for EFD/EFA,NW regional requirements. Selection or deselection of a tailoring option will include or exclude that option in the section. Editing of the resulting section to fit the project is still required.

Comments and suggestion on this specification are welcome and should be directed to the technical proponent of the specification. A listing of the technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

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NOTE: INSTRUCTIONS TO VIEW/PRINT GRAPHICS

FROM CCB DISKS OR WEBSITE:

1. Put in Disk A and go to CCB Program, or go to www.ccb.org and sign in.
2. Choose Library.
3. Choose Specifications.
4. Choose NAVFAC Guide Specifications (English) or (Metric) graphics.
5. Open the file you need.

FROM ENGINEERING INNOVATION AND CRITERIA WEB PAGE: http://criteria.navfac.navy.mil

1. Choose "Unified Facilities Guide Specifications" link from the left.

2. Choose link for "GRAPHICS".

3. Scroll to Section graphic, English or Metric as needed, pdf file.

4. Limited graphics are available in DWG format. Request availablility from cgs@efdlant.navfac.navy.mil

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NOTE: Two options for the QC Manager duties have been incorporated into this guide specification. The first option allows the QC Manager to perform production related duties and the second option does not. Both options can include the use of QC specialists responsible for performing QC for specific areas of work and for a specified frequency. Specify QC specialists for those areas of work that are of sufficient complexity or size to justify the expense.

Determine whether a full time QC Manager is justified or whether it would be more cost effective to designate the project superintendent as the QC Manager, i.e. to act in a dual role. Consider:

1. Design and complexity of project;

2. Location of project;

3. Cost and type of Contract;

4. Characteristics of area construction labor market;

5. Amount and type of off-site fabrication.

6. Duration of project.

When requiring the use of a Registered Professional Engineer/Architect or a graduate Engineer/Architect for the QC Manager or QC specialist(s), keep in mind the additional cost. The over-specifying of expertise for QC personnel should be avoided.
****

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 880	(1995) Criteria for Use in Evaluation of Testing Laboratories and Organizations for Examination and Inspection of Steel, Stainless Steel, and Related Alloys
ASTM C 1077	(2002) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM D 3666	(2002) Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D 3740	(2001) Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
ASTM E 329	(2002) Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction
ASTM E 543	(2002) Agencies Performing Nondestructive Testing

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(1996) Safety and Health Requirements Manual

Appendix C

"Analytical Methods Supporting the Experimental Design"

ASTM STANDARDS

A 36/ A 36M	Specification for Carbon Structural Steel
B 117	Practice for Operating Salt Spray (Fog) Apparatus
D 476	Classification for Dry Pigmentary Titanium Dioxide Pigments
D 512	Test Methods for Chloride Ion in Water
D 520	Specification for Zinc Dust Pigment
D 521	Test Methods for Chemical Analysis of Zinc Dust (Metallic Zinc Powder)
D 523	Test Method for Specular Gloss
D 562	Test Method for Consistency of Paints Measuring Krebs Unit (KU) Viscosity Using the Stormer -Type Viscometer
D 610	Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces
D 714	Test Method for Evaluating Degree of Blistering of Paints
D 1186	Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base
D 1475	Test Method for Density of Liquid Coatings, Inks, and Related Products
D 1640	Test Methods for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature
D 1652	Test Method for Epoxy Content of Epoxy Resins
D 1654	Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

D 2073	Test Methods for Total, Primary, Secondary, and Tertiary Amine Values of Fatty Amines, Amidoamines, and Diamines by Referee Potentiometric Method
D 2196	Test Method for Rheological Properties of Non -Newtonian Materials by Rotational (Brookfield -Type) Viscometer
D 2240	Test Method for Rubber Property—Durometer Hardness
D 2244	Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates
D 2369	Test Methods for Volatile Content of Coatings
D 2371	Test Method for Pigment Content of Solvent-Reducible Paints
D 2697	Test Method for Volume Nonvolatile Matter in Clear or Pigmented Coatings
D 2698	Test Method for the Determination of the Pigment Content of Solvent-Reducible Paints by High -Speed Centrifuging
D 3335	Test Method for Low Concentrations of Lead, Cadmium, and Cobalt in Paint by Atomic Absorption Spectroscopy
D 3718	Test Method for Low Concentrations of Chromium in Paint by Atomic Absorption Spectroscopy
D 3960	Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings
D 4060	Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
D 4285	Test Method for Indicating Oil or Water in Compressed Air
D 4400	Test Methods for Sag Resistance of Paints Using a Multinotch Applicator
D 4417	Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel
D 4541	Test Method for Pull-Off Strength of Coatings Using Portable

	Adhesion Testers
D 4940	Test Method for Conductimetric Analysis of Water-Soluble Ionic Contamination of Blasting Abrasives
D 5894	Standard Practice for Cyclic Salt Fog/UV Exposure of Painted Metal
D 6580	Standard Test Method for the Determination of Metallic Zinc Content in Both Zinc Dust Pigment and in Cured Films of Zinc Dust Pigment and in Cured Films of Zinc -Rich Coatings
E 11	Specification for Wire-Cloth and Sieves for Testing Purposes
E 1349	Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional Geometry
G 92	Practice for Characterization of Atmospheric Test Sites
G 140	Standard Method for Determining Atmospheric Chloride Deposition Rate by Wet Candle Method

FEDERAL STANDARDS

Fed. Std. No. 40	CFR 51.100(s) Volatile Organic Compound Definition
Fed. Std. No. 40	CFR 59.406(a) Volatile Organic Compound Compliance Provision
Fed. Std. No. 40	CFR Part 59, Subpart D, Section 59.400 Through 59.413 National Volatile Organic Compound Emission Standards for Architectural Coatings
Fed. Std. No. 40	CFR 261.24, Table 1 Maximum Concentration of Contaminants for the Toxicity Characteristic
Fed. Std. No. 595	Colors Used in Government Procurement
EPA-SW846, Method 1311	Toxicity Characteristic Leaching Procedure (TCLP)

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

AB-3	Abrasive Specification Number 3, Newly Manufactured or Re-Manufactured Steel Abrasive
Guide 9	Guide for Atmospheric Testing of Coatings in the Field

PA 2	Measurement of Dry Paint Thickness with Magnetic Gages
Paint 20	Zinc-Rich Primers
SP 5	White Metal Blast Cleaning
SP 6	Commercial Blast Cleaning
SP 10	Near-White Blast Cleaning

Appendix D

AASHTO R31-02 Laboratory Data

CORROSION • CONTROL • CONSULTANTS • AND LABS, INC.

AASHTO CERTIFICATE OF COMPLIANCE

We hereby certify that this coating system manufactured by **Polyspec Company**, which is composed of Polyspec LPE 5020 and Polyspec Ultra, was tested in accordance with the requirements for each applicable test as defined by AASHTO R31, its support specifications and that all information presented is truthful and without bias.

All records and documents pertaining to this certificate and not submitted herewith will be maintained available by the undersigned for a period of not less than seven years.

Barbara A. Doezema

Barbara A. Doezema, Paint Laboratory Manager

Karen J. Tinklenberg

Karen Tinklenberg, Quality Assurance Manager

Gary Tinklenberg, Technical Director

subscribed and sworn before me this

10 th day of May , 2004

Susan J. Hoffman

Signature of Notary Public

my commission expires on May 7, 2006

4403 DONKER CT. • KENTWOOD, MI 49512-4054 • 616-940-3112 • FAX: 616-940-8139 • WEB-SITE: www.ccclabs.com

AASHTO Designation: R 31-02
Test No. 7 (8.7)
Coating Identification Tests

System Number: 2003-03

Product Name: Thiokol LPE 5020

	Manufacturer's Listed Value	Test Result	
VOC	0.02	65.6 g/L	
Total Solids (% by mass)	99.8%	95.7%	94.2%
Pigment (% by mass)	not given	NA	NA
Metallic Zinc (% by mass)	none	NA	
Total Solids (% by vol)	99.7%	90.7%	91.0%
Mass per Vol	not given	1314.5 g/L	1303.2 g/L
Viscosity (Stormer @ 25° C)	not given	NA	NA
Viscosity (Brookfield @ 25° C)	not given	NA	NA
Pot Life (Hours)	15-20 minutes	NA	
Sag Resistance	not given	26 mls wft	
Recommended Min DFT	not given		
Recommended Max DFT	not given		
Max DFT Faying Surfaces (Primer)	not applicable		
Theoretical Coverage	not given		
Min Drying Time to Touch	2 hours	30 minutes	
Min Drying Time to Handle	2 hours	1 hour	
Min Drying Time to Recoat	2 hours	2 hours	
Max Drying Time to Recoat	not given	NA	
Mixing Ratio (by vol)	1/2		
Mixing Ratio (by mass)	154.27/307.2		
Total Lead		<0.0050%	
Total Chromium		<0.0013%	
Total Cadmium		<0.00075%	
TCLP Arsenic		<0.20 ppm	
TCLP Barium		<0.50 ppm	
TCLP Cadmium		<0.030 ppm	
TCLP Chromium		<0.050 ppm	
TCLP Lead		<0.20 ppm	
TCLP Mercury		<0.0010 ppm	
TCLP Selenium		<0.20 ppm	
TCLP Silver		<0.050 ppm	
Epoxides	not given	9800 grams	
Amines	not given	20.3	

Isocyanates	not given	NA
HALS	not given	NA

Notations & Deviations: This coating is a plural component coating and does not contain zinc, therefore some of the testing cannot be performed.

AASHTO Designation: R 31-02
Test No. 7 (8.7)
Coating Identification Tests

System Number: 2003-03

Product Name: Ultra

	Manufacturer's Listed Value	Test Result	
VOC	2 lbs/gal	2.6 lbs/gal	
Total Solids (% by mass)	82.7%	71.1%	70.9%
Pigment (% by mass)	not given	5.0%	5.0%
Metallic Zinc (% by mass)	none	NA	
Total Solids (% by vol)	70.4%	62.9%	62.8%
Mass per Vol	not given	1063.3 g/L	1061.1 g/L
Viscosity (Stormer @ 25° C)	not given	74 KU	74 KU
Viscosity (Brookfield @ 25° C)	not given	1060 cpds	1063 cpds
Pot Life (Hours)	3 hours	3 hours	
Sag Resistance	not given	8.4 mils wft	
Recommended Min DFT	2 mils		
Recommended Max DFT	3 mils		
Max DFT Faying Surfaces (Primer)	not applicable		
Theoretical Coverage	35-53 sq.m/3.78L		
Min Drying Time to Touch	2 hours	2 hours	
Min Drying Time to Handle	4.5 hours	3 hours	
Min Drying Time to Recoat	4.5 hours	4.5 hours	
Max Drying Time to Recoat	not given	NA	
Mixing Ratio (by vol)	5/1		
Mixing Ratio (by mass)	not given		
Total Lead		<0.0050%	
Total Chromium		<0.0013%	
Total Cadmium		<0.00075%	
TCLP Arsenic		<0.20 ppm	
TCLP Barium		<0.50 ppm	
TCLP Cadmium		<0.030 ppm	
TCLP Chromium		<0.050 ppm	
TCLP Lead		<0.20 ppm	
TCLP Mercury		<0.0010 ppm	
TCLP Selenium		<0.20 ppm	
TCLP Silver		<0.050 ppm	

Epoxides	not given	NA
Amines	not given	NA
Isocyanates	not given	22.5 %
HALS	not given	NA
Notations & Deviations		

Note: The correct VOC units should be g/L NOT lbs/gal as shown.

AASHTO Designation: R 31-02
Test No. 4 (8.4)
Abrasion Resistance Test

System Number: 2003-03 Panel Number: 7 Test Date: 9/16/2003

		Wear Index mg/cycle	Weight Loss mg
Preweight, gm	71.5583	72.1	72.1
Postweight, gm	71.4862		

Notations & Deviations

AASHTO Designation: R 31-02
Test No. 4 (8.4)
Abrasion Resistance Test

System Number: 2003-03 Panel Number: 8 Test Date: 9/16/2003

		Wear Index mg/cycle	Weight Loss mg
Preweight, gm	70.2777	60.6	60.6
Postweight, gm	70.2171		

Notations & Deviations

AASHTO Designation: R 31-02
Test No. 4 (8.4)
Abrasion Resistance Test

System Number: 2003-03 Panel Number: 9 Test Date: 9/16/2003

		Wear Index mg/cycle	Weight Loss mg
Preweight, gm	70.824	54.9	54.9
Postweight, gm	70.7691		

Notations & Deviations

AASHTO Designation: R 31-02
Test No. 5 (8.5)
Adhesion Test

System Number: 2003-03 Panel Number: 10 Test Date: 9/17/2003

	MPa	Failure
Pull #1	4.2	100% cohesion-primer
Pull #2	4.8	100% cohesion-primer
Pull #3	4.2	100% cohesion-primer
Pull #4	4.5	100% cohesion-primer

Notations & Deviations

AASHTO Designation: R 31-02
Test No. 5 (8.5)
Adhesion Test

System Number: 2003-03 Panel Number: 11 Test Date: 9/17/2003

	MPa	Failure
Pull #1	4.8	100% cohesion-primer
Pull #2	5.1	100% cohesion-primer
Pull #3	4.5	100% cohesion-primer
Pull #4	4.8	100% cohesion-primer

Notations & Deviations

AASHTO Designation: R 31-02
Test No. 5 (8.5)
Adhesion Test

System Number: 2003-03 Panel Number: 12 Test Date: 9/17/2003

	MPa	Failure
Pull #1	4.5	100% cohesion-primer
Pull #2	4.5	100% cohesion-primer
Pull #3	5.1	100% cohesion-primer
Pull #4	3.1	50% cohesion-primer/50% glue

Notations & Deviations

AASHTO Designation: R 31-02
Test No. 5 (8.5)
Adhesion Test

System Number: 2003-03 Panel Number: 13 Test Date: 9/17/2003

	MPa	Failure
Pull #1	4.2	80% cohesion-primer/20% glue
Pull #2	3.9	80% cohesion-primer/20% glue
Pull #3	4.2	100% cohesion-primer
Pull #4	4.8	100% cohesion-primer

Notations & Deviations

AASHTO Designation: R 31-02
Test No. 5 (8.5)
Adhesion Test

System Number: 2003-03 Panel Number: 14 Test Date: 9/17/2003

	MPa	Failure
Pull #1	3.9	90% cohesion-primer/10% glue
Pull #2	3.4	75% cohesion-primer/25% glue
Pull #3	4.8	75% cohesion-primer/25% glue
Pull #4	3.6	85% cohesion-primer/15% glue

Notations & Deviations

AASHTO Designation: R 31-02
Test No. 5 (8.5)
Adhesion Test

System Number: 2003-03 Panel Number: 15 Test Date: 9/17/2003

	MPa	Failure
Pull #1	3.9	75% cohesion-primer/25% glue
Pull #2	3.6	80% cohesion-primer/20% glue
Pull #3	4.5	80% cohesion-primer/20% glue
Pull #4	4.5	50% cohesion-primer/50% glue

Notations & Deviations

AASHTO Designation: R 31-02
Test No. 8 (8.8)
Two-Year Atmospheric Testing

System Number: 2003-03 Panel Number: 19 Start Date: 9/23/2003

	Gloss	Δe	Color Change	L	A	B	C	H
Baseline	65.4			26.2	-26.1	9.49	27.75	160
2 Years								

	Blistering	Rust Creepage at the Scribe Max	Rust Creepage at the Scribe Avg	% Rusting at the Scribe Edges	Rusting in the Scribe
2 Years					
After Scraping					

Notations & Deviations

AASHTO Designation: R 31-02
Test No. 8 (8.8)
Two-Year Atmospheric Testing

System Number: 2003-03 Panel Number: 20 Start Date: 9/23/2003

	Gloss	Δe	Color Change	L	A	B	C	H
Baseline	57.7			25.99	-26.4	9.69	28.12	159.8
2 Years								

	Blistering	Rust Creepage at the Scribe Max	Rust Creepage at the Scribe Avg	% Rusting at the Scribe Edges	Rusting in the Scribe
2 Years					
After Scraping					

Notations & Deviations

AASHTO Designation: R 31-02
Test No. 8 (8.8)
Two-Year Atmospheric Testing

System Number: 2003-03 Panel Number: 21 Start Date: 9/23/2003

	Gloss	Δe	Color Change	L	A	B	C	H
Baseline	59.1			26.03	-26.4	9.7	28.12	159.8
2 Years								

	Blistering	Rust Creepage at the Scribe Max	Rust Creepage at the Scribe Avg	% Rusting at the Scribe Edges	Rusting in the Scribe

2 Years						
	After Scraping					

Notations & Deviations

AASHTO Designation: R 31-02
Test No. 8 (8.8)
Two-Year Atmospheric Testing

System Number: 2003-03 Panel Number: 22 Start Date: 9/23/2003

	Gloss	Δe	Color Change	L	A	B	C	H
Baseline	57.3			25.8	-26.3	9.64	28.02	159.9
2 Years								

		Blistering	Rust Creepage at the Scribe Max	Rust Creepage at the Scribe Avg	% Rusting at the Scribe Edges	Rusting in the Scribe
2 Years						
	After Scraping					

Notations & Deviations

AASHTO Designation: R 31-02
Test No. 8 (8.8)
Two-Year Atmospheric Testing

System Number: 2003-03 Panel Number: 23 Start Date: 9/23/2003

	Gloss	Δe	Color Change	L	A	B	C	H
Baseline	51.3			25.86	-26.3	9.7	28.1	159.8
2 Years								

		Blistering	Rust Creepage at the Scribe Max	Rust Creepage at the Scribe Avg	% Rusting at the Scribe Edges	Rusting in the Scribe
2 Years						
	After Scraping					

Notations & Deviations

AASHTO Designation: R 31-02
Test No. 3 (8.3)
ASTM D 5894 Cyclic Weathering Resistance Test

System Number: 2003-03 Panel Number: 4 Start Date: 9/16/2003

	Gloss	Color Change Δe	L	A	B	C	H
Baseline	58.7		25.6	-26.2	9.69	27.93	159.7
3 Cycles	53.1	1.5	26.05	-24.8	9.55	26.56	158.9
6 Cycles	53.3	2.3	26.61	-24.2	9.29	25.9	159
9 Cycles	37.6	7.3	29.01	-21.4	7.56	23.64	162
12 Cycles	19	11.6	33.25	-18.7	5.19	19.42	164.5
15 Cycles	18.4	11.3	33.12	-19.0	5.38	19.78	164.2

	Blistering	Rust Creepage at the Scribe Max	Rust Creepage at the Scribe Avg	% Rusting at the Scribe Edges	Rusting in the Scribe
3 Cycles	10	8.5	2.0		Completely Rusted
6 Cycles	10	8.5	3.1		Completely Rusted
9 Cycles	10	12.5	5.9		Completely Rusted
12 Cycles	10	16	8.2		Completely Rusted
15 Cycles	10	18	9.5		Completely Rusted
After Scraping		18	13.1	100	Completely Rusted

Notations & Deviations

AASHTO Designation: R 31-02
Test No. 3 (8.3)
ASTM D 5894 Cyclic Weathering Resistance Test

System Number: 2003-03 Panel Number: 5 Start Date: 9/16/2003

	Gloss	Color Change Δe	L	A	B	C	H
Baseline	61.7		25.88	-29.2	9.68	27.92	159.7
3 Cycles	60.1	1.5	26.62	-24.9	9.44	26.65	159.3
6 Cycles	57	2.2	26.76	-24.3	9.13	25.96	159.4
9 Cycles	38.4	8.1	30.04	-21.2	7.89	24.01	162.4
12 Cycles	18	12.1	34.41	-19.0	4.92	19.67	165.5
15 Cycles	18.1	12.7	34.35	-18	5.04	18.66	164.3

	Blistering	Rust Creepage at the Scribe Max	Rust Creepage at the Scribe Avg	% Rusting at the Scribe Edges	Rusting in the Scribe
3 Cycles	10	3	0.6		Completely Rusted
6 Cycles	10	11.5	2.7		Completely Rusted
9 Cycles	10	14.5	6.3		Completely Rusted
12 Cycles	10	21	9.3		Completely Rusted
15 Cycles	10	21	10.6		Completely Rusted

After Scraping	21	10.8	100	Completely Rusted

Notations & Deviations

AASHTO Designation: R 31-02
Test No. 3 (8.3)
ASTM D 5894 Cyclic Weathering Resistance Test

System Number: 2003-03 Panel Number: 6 Start Date: 9/16/2003

	Gloss	Color Change Δe	L	A	B	C	H
Baseline	56.1		25.98	-26.2	9.59	27.86	159.9
3 Cycles	53.3	1.4	26.47	-24.9	9.44	26.59	159.2
6 Cycles	48	1.7	26.58	-24.6	9.33	26.31	159.2
9 Cycles	37.6	8	30.64	-21.7	7.98	23.86	162
12 Cycles	24.1	11	33.55	-19.5	5.34	20.21	164.7
15 Cycles	22.4	10.4	32.66	-19.2	5.86	20.05	163

	Blistering	Rust Creepage at the Scribe Max	Rust Creepage at the Scribe Avg	% Rusting at the Scribe Edges	Rusting in the Scribe
3 Cycles	10	5	1.2		Completely Rusted
6 Cycles	10	9.5	2.4		Completely Rusted
9 Cycles	10	11	4.1		Completely Rusted
12 Cycles	10	14	7.7		Completely Rusted
15 Cycles	10	17	8.8		Completely Rusted
After Scraping		17	9	100	Completely Rusted

Notations & Deviations

AASHTO Designation: R 31-02
Test No. 2 (8.2)
Salt Fog Resistance Test

System Number: 2003-03 Panel Number: 1 Start Date: 9/16/2003

	Blistering	Rust Creepage at the Scribe Max	Rust Creepage at the Scribe Avg	% Rusting at the Scribe Edges	Rusting in the Scribe
1000 Hours	10	0	0		Completely Rusted
2000 Hours	10	0	0		Completely Rusted
3000 Hours	10	0	0		Completely Rusted
4000 Hours	10	0	0		Completely Rusted
5000 Hours	10	10	1.4		Completely Rusted
After Scraping		10	1.6	46	Completely Rusted

Notations & Deviations: starting at the 4000 hour mark, the topcoat appeared to be delaminating from the primer

AASHTO Designation: R 31-02
Test No. 2 (8.2)
Salt Fog Resistance Test

System Number: 2003-03 Panel Number: 2 Start Date: 9/16/2003

	Blistering	Rust Creepage at the Scribe Max	Rust Creepage at the Scribe Avg	% Rusting at the Scribe Edges	Rusting in the Scribe
1000 Hours	10	0	0		Completely Rusted
2000 Hours	10	0	0		Completely Rusted
3000 Hours	10	0	0		Completely Rusted
4000 Hours	10	0	0		Completely Rusted
5000 Hours	10	5	1.0		Completely Rusted
After Scraping		6	1.2	30	Completely Rusted

Notations & Deviations: starting at the 4000 hour mark, the topcoat appeared to be delaminating from the primer

AASHTO Designation: R 31-02
Test No. 2 (8.2)
Salt Fog Resistance Test

System Number: 2003-03 Panel Number: 3 Start Date: 9/16/2003

	Blistering	Rust Creepage at the Scribe Max	Rust Creepage at the Scribe Avg	% Rusting at the Scribe Edges	Rusting in the Scribe
1000 Hours	10	0	0		Completely Rusted

2000 Hours	10	0	0		Completely Rusted
3000 Hours	10	0	0		Completely Rusted
4000 Hours	10	0	0		Completely Rusted
5000 Hours	10	15	2.9		Completely Rusted
After Scraping		15	3.1	45	Completely Rusted

Notations & Deviations: starting at the 4000 hour mark, the topcoat appeared to be delaminating from the primer